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April 2004

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LX200GPS

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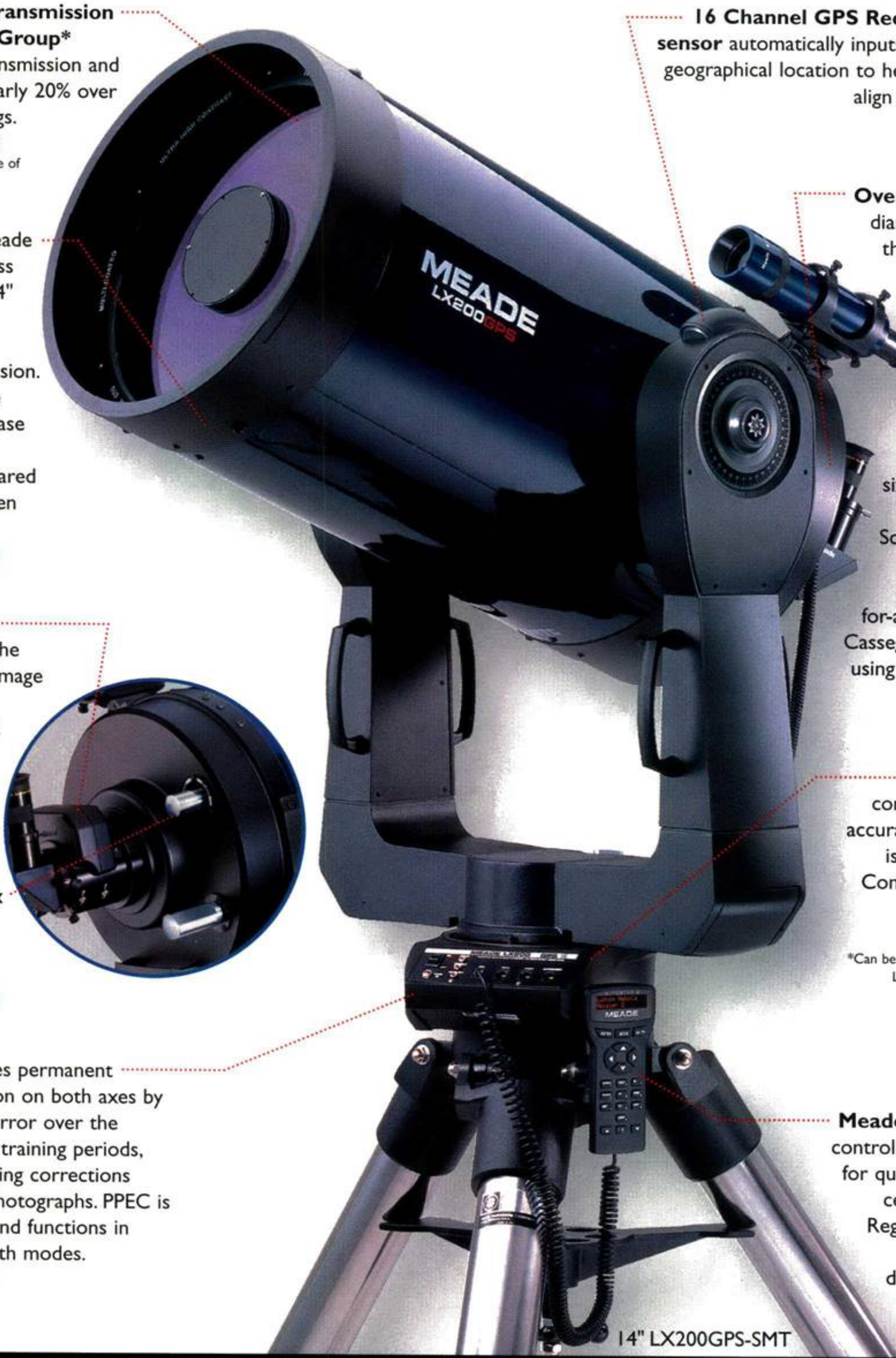

14" LX200GPS-SMT

Meade Ultra-High Transmission Coatings (UHTC™) Group* increases total light transmission and image brightness by nearly 20% over Meade standard coatings.

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*Available as an option only at time of purchase.

Optical System – Meade utilizes water white glass in all 8", 10", 12", and 14" Schmidt-Cassegrain corrector lenses to maximize light transmission. The use of water white glass results in an increase of light transmission in excess of 10% as compared to telescopes using green soda lime glass.

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MEADE EXCLUSIVE

Primary Mirror Lock locks mirror in place during long-exposure photography.

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Meade Autostar II handbox controller features "Hot Keys" for quick access to a 145,000 celestial object database. Regular software upgrades are available as a free download at *meade.com*.

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Manufactured under U.S. Patent Nos. 6,304,376, 6,392,799 and 6,563,636; other patents pending in the U.S.A. and worldwide.

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For over three decades, Meade Instruments has been driving astronomical discovery through product innovations exclusive to Meade Instruments. Our engineering group (the largest in the industry) has the unique expertise and resources to design and manufacture precision optics, advanced mechanical technology, and patented innovations into every telescope we make. We don't go to these lengths just to stay number one – we do it because astronomy is our passion.

Suggested U.S. national mail-order retail prices for LX200GPS-SMT models:

Model	Price	LPI/Autostar Suite	UHTC Group	Shipping & Handling*
8" LX200GPS-SMT	$2195	Free ($149 value)	$175	$105
10" LX200GPS-SMT	$2745	Free ($149 value)	$235	$145
12" LX200GPS-SMT	$3595	Free ($149 value)	$295	$215
14" LX200GPS-SMT	$4995	Free ($149 value)	$350	$265
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MEADE UHTC Group is a series of exotic optical coatings precisely tuned to optimize the visual, photographic and CCD imaging performance of your LX-Series telescope. Image brightness is increased by nearly 20% over standard Meade coatings. Objects such as stars, galaxies and nebulae as observed through your telescope will be dramatically brighter. Even observation of the Moon and planets will benefit in increased image brightness from the full spectrum of light transmission.

* The Meade Ultra-High Transmission Coatings group must be ordered at the time of telescope purchase. The UHTC cannot be retrofitted.

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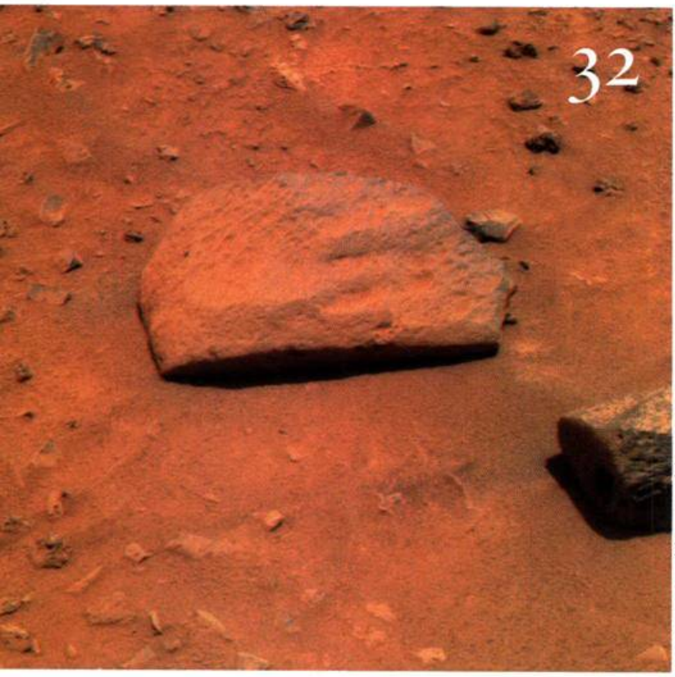

MARS ROCKS SASHIMI (L) AND SUSHI (R). NASA/JPL/CORNELL

NASA AND THE HUBBLE HERITAGE TEAM (STSCI/AURA)

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Kalmbach Publishing Co., 21027 Crossroads
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ON THE COVER

The rolling hills in the distance mark the horizon to the east of the Columbia Memorial Station, the name given to the Mars Rover Spirit's landing site in Gusev Crater. Mission scientists are directing the rover to examine rocks and soil around the landing site, as they seek traces of water early in the Red Planet's history. NASA/JPL/CORNELL

BY DAVID J. EICHER

Return to the Red Planet

As earthlings stand once again on the threshold of invading Mars, we have mixed news of success. Thank goodness the two Mars Exploration Rovers (MERs), Spirit and Opportunity, are operating perfectly well. Spirit landed at Gusev Crater on January 3, rolled off its platform twelve days later, and began exploring what was once a lake, possibly with traces of former Mars life. The other rover, Opportunity, landed at Meridiani Planum on January 25 UT. Unfortunately, both the Japanese atmospheric probe Nozomi and the European lander Beagle 2 appear to be inoperative. Those are tragic losses for Mars exploration.

NASA's rovers will no doubt give us breathtaking, unprecedented views of the martian landscape and an expanded knowledge of previously water-rich areas on the planet. *Astronomy* sent space journalist Bruce Moomaw for a behind-the-scenes look at the MER landings at the Jet Propulsion Laboratory in Pasadena, California, this January. Moomaw has been intensely interested in space exploration since 1964. A regular writer for Simon Mansfield's "SpaceDaily" aerospace news web site, Moomaw played a role in helping prevent the cancellation of the 2006 mission to Pluto by suggesting a reduced-cost method to carry the mission forward. Moomaw's exclusive inside story of the Spirit landing, "Spirit lands at Gusev," begins on page 32.

The editors of *Astronomy* don't want you to think only of the current Mars excitement, however. Senior editor Robert Burnham has written a story featuring spellbinding images of Mars past and present created by Dutch amateur astronomer and Internet specialist Kees Veenenbos. In his spare time, Veenenbos uses the landscape program *Terragen* and Mars data to create "3-D" pictures of the Red Planet, adding color to simulate Mars's watery past. Burnham's story, "Envisioning Mars," appears on page 38.

ADIRONDACK ROCK was the first target for the Spirit rover at Gusev Crater. On page 32, science writer Bruce Moomaw takes you to Mars via NASA's Jet Propulsion Laboratory. NASA/JPL

You also will not want to miss Steve Nadis's cosmological profile, "The lost years of Michael Turner," on page 44. Now one of the top cosmologists in the world, Turner was once a Stanford graduate student who took some time off to fix Porsches and volunteer for experiments to make ends meet. Turner's lost years story is an amazing one to behold.

Yours truly,

Dave Eicher
Editor

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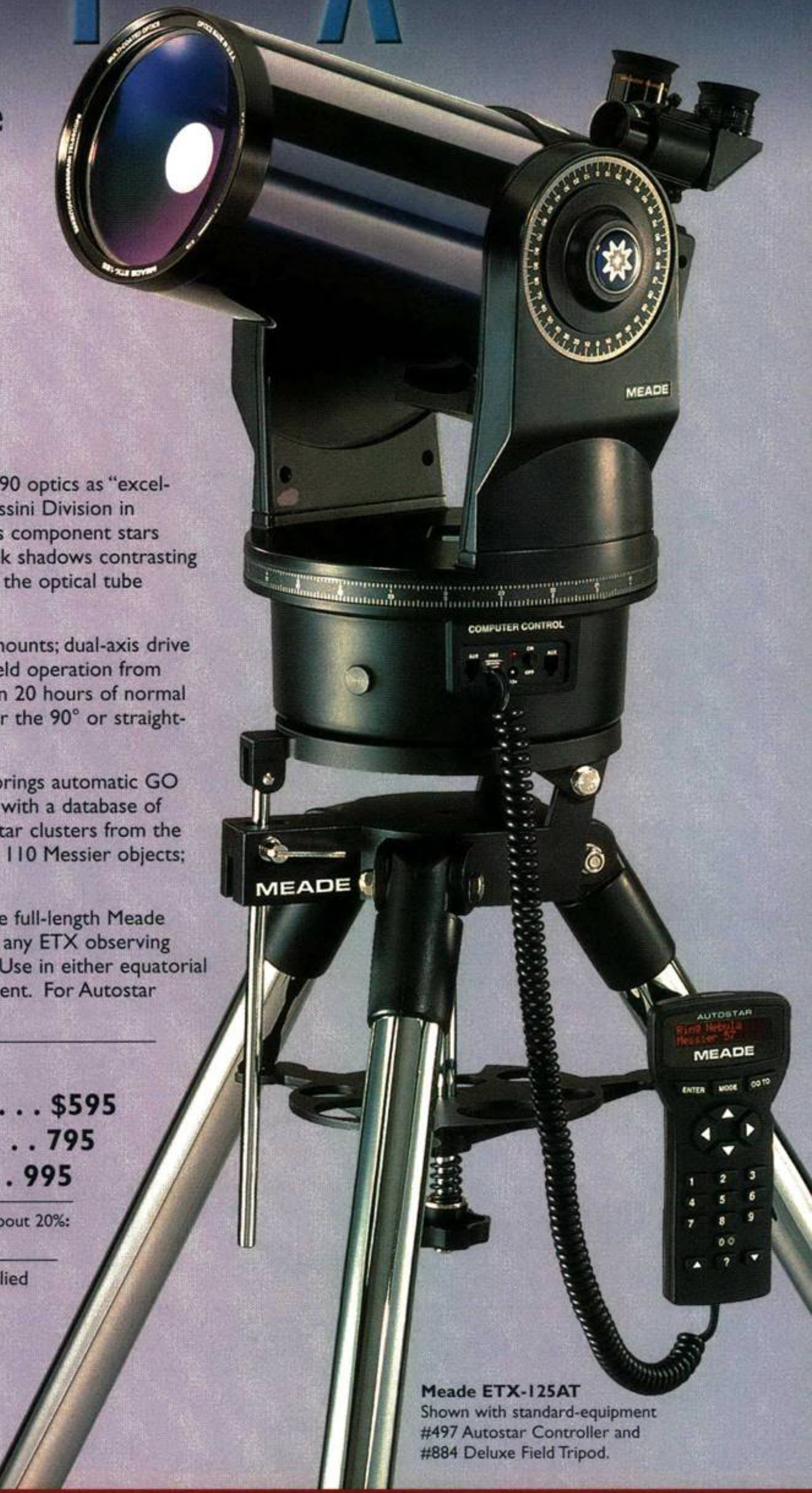

Matchless diffraction-limited optics: *Sky & Telescope* described ETX-90 optics as "excellent…stellar diffraction patterns were virtually textbook-perfect…the Cassini Division in Saturn's rings popped into view despite the rings' low tilt…Epsilon Lyrae's component stars were cleanly split…the Moon was beautiful at any magnification, with black shadows contrasting sharply with illuminated features along the terminator…the mechanics of the optical tube assembly are also first rate."

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ETX-90AT Astro Telescope	**$595**
ETX-105AT Astro Telescope	**795**
ETX-125AT Astro Telescope	**995**

Ultra-High Transmission Coatings (UHTC) group increases image brightness by about 20%: ETX-90AT– $50; ETX-105AT– $75; ETX-125AT– $95

Alternately, for the beginning-to-intermediate observer, the ETX-70AT is supplied with #494 Autostar Controller and #882 Field Tripod:

ETX-70AT Astro Telescope	**299**

Packing & shipping (ETX, Autostar, & Tripod): ETX-90AT — $30; ETX-105AT — $35; ETX-125AT — $40; ETX-70AT — $20.

Meade ETX-125AT
Shown with standard-equipment #497 Autostar Controller and #884 Deluxe Field Tripod.

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#911B

#908B

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#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. **99.95** (5.26)

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#908X

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f/6.3 FOCAL REDUCER/FIELD

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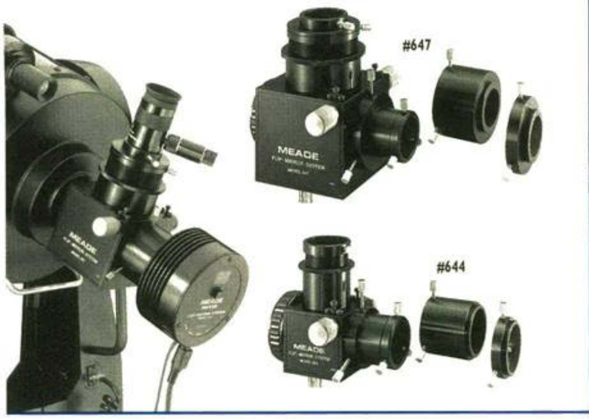
Use with ***any*** brand of CCD imager or for astrophotography with a 35mm camera. Flip mirror "down" to center the image while viewing with an eyepiece at 90°; flip mirror "up" to pass light on to CCD chip or 35mm camera film plane. Each unit includes: precision optical-flat Pyrex® mirror; 2-axis mirror-adjustment for precise image centering; extra-fine helicoid focusing of the eyepiece; extension tubes for 35mm camera (using T-Mount) or CCD imager (using either T-threads or 1.25" barrel). Threads to rear cells of all Schmidt-Cassegrain telescopes; may remain on telescope and used in place of diagonal prism for visual observing as well.

#644 Flip-Mirror System: Accepts any 1.25" eyepiece. Mirror clear aperture: 22mm. Use with CCD's up to Pictor 416XTE, ST-7, or AP1, or smaller; or visual observing with 1.25" eyepieces. **$149.95** (7.02)

#647 Flip-Mirror System: Accepts either 1.25" or 2" eyepieces. Mirror clear aperture: 40mm. Recommended for full-field 35mm astrophotography or with CCD's of any size, including all Meade Pictor Series through 1616XTE, or ST-4 through ST-10; or AP2, AP7; or for visual applications with 1.25" or 2" eyepieces. **249.95** (8.49)

#157 1.25" Adapter: Permits use of either Flip-Mirror on telescopes with 1.25" eyepiece-holders. (Requires approx. 2" additional focus travel with #644, 3" with #647.) **15.00** (3.86)



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Rigidly couples 35mm camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

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.965": $27.95; 1.25": $29.95 (3.86)

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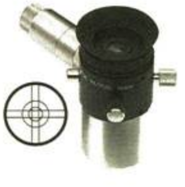

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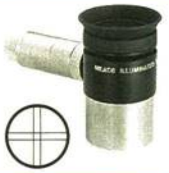

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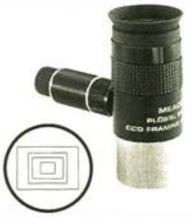

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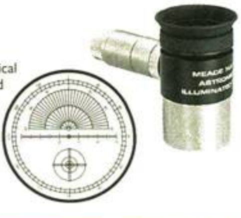

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(below, left to right) 8" Model SC-8 Schmidt-Cassegrain; 5" Model AR-5 and 6" Model AR-6 Achromatic Refractors.

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Rigid chromed-steel variable-height field tripod — *the same tripod provided with Meade LX200GPS models.*

Autostar™ Computer Controller: The LX90's *standard-equipment* Autostar controller permits an incredible array of telescope features:

- *Automatic GO TO capability* at 6.5°/sec on both axes, simultaneously, to 30,223 database objects, including:
  - 13,235 deep-sky objects — the complete Messier, Caldwell, IC, and NGC catalogs; 16,888 stars; the 8 major planets; the Moon; 26 asteroids; 15 comets; 50 Earth satellites; plus 200 user-defined memory locations.
- *Automatic GO TO capability* to any object of known R.A. and Declination. Plus hundreds of special event menus, guided tours, utility functions, and telescope status options.
- *Nine selectable slew speeds:* 6.5°/sec, 3°/sec, and 1.5°/sec, as well as 128x, 64x, 16x, 8x, 2x, and 1x sidereal.
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- *Fast alignment of the telescope* using any of three alignment functions, including the Meade-proprietary Easy Align.
- *Autostar is fully upgradeable over the Internet:* add the positions of new comets, update the positions of Earth satellites, even add new software.

With diffraction-limited optics in an Autostar computer-controlled telescope system, the Meade 8" LX90 includes capabilities not available on other brands of 8" Schmidt-Cassegrains costing hundreds of dollars more. Incorporating the optical system of the 8" LX200GPS, and with 5 arc-minute pointing precision in the GO TO mode, the LX90 is fully qualified for long-exposure CCD imaging and astrophotography as well as for other advanced photo-visual applications.

8" LX90
Schmidt-Cassegrain
$1695

SPECIFICATIONS: 8" LX90 — Each complete telescope includes 8" f/10 Schmidt-Cassegrain optical tube assembly with MgF_2 coatings on the correcting lens and standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally; see below); double-tine fork mount with dual-axis 4.9" worm gears and control panel; electric slow-motion controls on both axes; Autostar hand controller with digital readout display, 9-speed drive controls on both axes, and GO TO controller; 30,223-object onboard celestial software library; internal battery port accepts 8 (user-supplied) C-cells (optional 25 ft. cords permit powering from either 12vDC auto cigarette lighter plug or from 115vAC home outlet); 8 x 50mm viewfinder; 1.25" diagonal prism; Series 4000 Super Plössl 26mm eyepiece; standard field tripod; Autostar Suite with imager; operating instructions. **$1695.** **Ultra-High Transmission Coatings (UHTC) group** increases image brightness by about 20%: add **$175.** Packing & shipping in the 48 states: $95.

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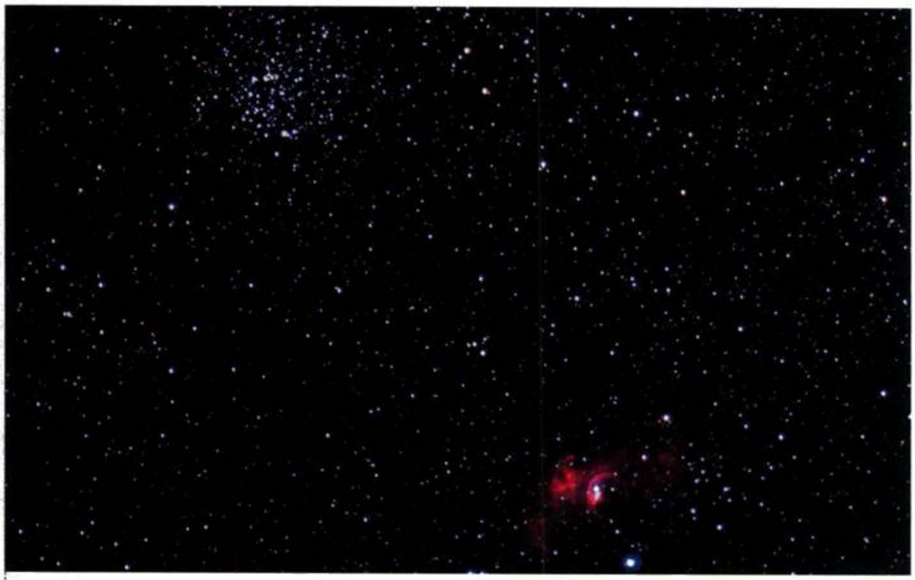
Deep-sky success

The discussion of Cassiopeia's hidden treasures in the deep-sky section of January's "The sky this month" delighted me. Like William Herschel did more than two centuries ago, I, too, stumbled on the Bubble Nebula while looking for M52. Unlike Herschel, my discovery was not made with my eyes, but with my CCD camera.



NGC 7635 (THE BUBBLE NEBULA) AND M52 (4-inch Astro-Physics refractor at f/6, SBIG ST-10XME CCD camera, LRGB image with exposures of 75, 15, 15, and 18 minutes, respectively) RUBEN KIER

I began the evening imaging open cluster M52 with my new CCD camera mounted on my 4-inch refractor. I chose M52 because it's a bright object that can be captured in just a few 3-minute exposures.

When a fuzzy patch appeared on the edge of my first image, I stretched my imaging session to more than forty exposures so I could see the mystery object better. I was thrilled to capture the Bubble Nebula and M52 in a single view!

I used to skip over the deep-sky section, thinking it was out of reach for my small telescope. But now with my CCD camera, the section comes alive with targets ripe for long-exposure imaging.
— **RUBEN KIER,** NEW HAVEN, CONNECTICUT

Sailing on a sunbeam

The November 2003 issue featured an article by James Oberg titled "Sailing on a sunbeam — at last?" As manager of NASA's In-Space Propulsion (ISP) Technology Projects Office at the Marshall Space Flight Center in Huntsville, Alabama, I was delighted to see your magazine providing coverage of the privately funded Cosmos-1 solar-sail package slated for launch in late January 2004. The final paragraph of the article, however, asserts NASA lacks plans to support solar-sail research and development, and that is incorrect.

The ISP program has been very much involved in solar-sail research since October 2002. During fiscal year 2003, two multi-million dollar contracts were awarded through a NASA Research Announcement (NRA) to two independent teams led by L'Garde and Able Engineering for the purpose of solar-sail research.

These two contracts are now in the second phase of designing, fabricating, and testing 20-meter-square solar-sail prototypes. Other supporting technical tasks are underway involving various NASA field centers, private industry, and educational institutions. The efforts of many talented and dedicated scientists and engineers are funded through this NASA program — totaling $8.7 million in fiscal year 2003 and $11.6 million in fiscal year 2004.

NASA plans to continue this level of investment into the future, supporting an eventual flight validation. All efforts are geared toward developing the best solar-sail design to serve as a platform for future science payloads. Our dedicated team at NASA would like the science community to be aware of our efforts toward maturing this very important technology.
— **LES JOHNSON,** MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, ALABAMA

Corrections

In "Reader gallery" (January 2004), the images of NGC 6781 and NGC 6537 on page 112 and NGC 4567 and NGC 4568 on page 113 were taken with a 20-inch RC Optical Systems Ritchey-Chrétien scope.

The four images featured in "Reader gallery" (February 2004) on pages 112 and 113 were incorrectly identified in the caption. The correct order as they are shown, left to right, is: M12, M29, M39, M26.
— ***ASTRONOMY* EDITORS**

We welcome your comments. Send letters to Astronomy Letters, P.O. Box 1612, Waukesha, WI 53187; e-mail to letters@astronomy.com. Please include your name, city, state, and country. Letters may be edited for space and clarity.

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{ BOB BERMAN'S STRANGE UNIVERSE } BY BOB BERMAN

True colors

“Have a look!” you say to a friend, stepping away from the eyepiece with an expectant smile. The target is M42, the Orion Nebula, one of the sky's showpieces, as it sinks toward the western horizon.

A strange expression crosses his face. He's seen photos of this great nebula, but the image through the eyepiece is unfamiliar. It lacks detail and is disappointingly devoid of color. As we've pointed out before, colorful objects at low light-levels appear dull gray. But as they say in *The Matrix*, “Welcome to the real world.”

Happy astrophotographers can create all the color they want. M42 can be contrast-boosted, saturated, repainted, accentuated — anything at all — using either high-speed film with an exaggerated sensitivity to the nebula's red emissions at 6563 angstroms or CCD and computer processing. It's Disneyland meets Orion. The eye can do none of these things. Result: Two separate universes are out there. One is the way things appear in magazine photos, the other is how they actually look through telescopes.

{ The result is a gorgeous portrait that bears no resemblance to either the Eagle Nebula's photographic appearance or how it looks through any telescope.

April is a good time to demonstrate these parallel realities. The Eagle Nebula in Serpens has returned from its annual hibernation behind the Sun and is up after midnight. Through a backyard telescope, this nebulosity looks gray and faint. With fast film and a long exposure, the nebulosity shows up as red because the crimson light emitted by hydrogen's infalling electrons produces most of its energy.

Fools that we are, we used to trust such photos. Then along came Jeff Hester and Paul Scowen at the University of Arizona, who used Hubble in 1995 to create the most famous astroimage of all time: the “Pillars of Creation.” And “creation” is exactly what they accomplished. I once spent an hour on the phone with Hester before he conceded the image wasn't realistic. Colors were computer-ascribed to black-and-white exposures in the light of hydrogen, oxygen, and sulfur. While scientifically useful, no attempt was made to present each color accurately. The result is a gorgeous portrait bearing no resemblance to either the Eagle's photographic appearance or how it looks through a telescope. It's about as natural as astro turf. Because a disclaiming “false color” caption seldom accompanies the image, the public thinks this psychedelic picture is the “real” Eagle Nebula. After seeing that, people observing M16 through *your* instrument likely will be as excited as if they were observing pond scum.

Day or night, the eye has its own bias against colors near the fringes of the spectrum, which is why the sky appears blue and not the true violet it really is. The retina's preference for green is the reason 8-inch and larger scopes depict Orion with a pale-lime glow, while film shows no green, portraying the nebula in blues and reds instead.

Even worse are the color distortions of planetary nebulae. Because 90 percent of their emissions comes from oxygen's green light at 5007 and 4959 angstroms, where the human eye has its peak sensitivity, the Ring, Dumbbell, and all others appear emerald through medium or large telescopes. The eye perceives how these objects actually look. But film prefers to register their weaker, minor emissions of blues and reds, which is how planetary nebulae often appear in books and magazines.

When we want to present friends with a view similar to those beautiful published photos, it's easy to do. Hundreds of targets look essentially the same through the eyepiece as they do when photographed.

It's simple, just avoid nebulae. Direct telescope views pretty much match the photographed image when the target is the Moon, Saturn, Venus, Mercury, or even Jupiter, as do views of the magnificent edgewise galaxy NGC 4565, all double stars like Albireo, all open clusters like M35 in Gemini or M41 in Canis Major. Here, the parallel universes unite.

Nighttime unveils weirder stuff, especially around spring break. Most flying saucers are plated in gold and iridium, but overzealous photographers like to colorize them turquoise. Aliens, who appear chartreuse if they're from the fashionable but pricey Tau Ceti system, usually are falsely portrayed as green. Is this a conspiracy created by Kodak and Fujicolor to re-paint the universe in our minds? Can you trust anyone? Are you the last person to know how the cosmos really looks? Re-read this article and combine the first word of every paragraph. Learn the hidden secret. ■

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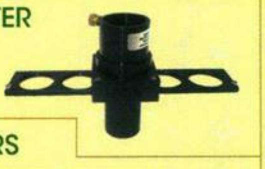

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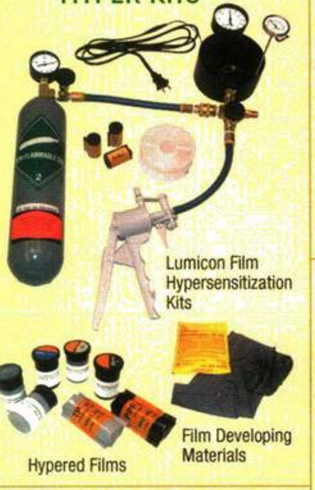
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{ GLENN CHAPLE'S OBSERVING BASICS }

BY GLENN CHAPLE

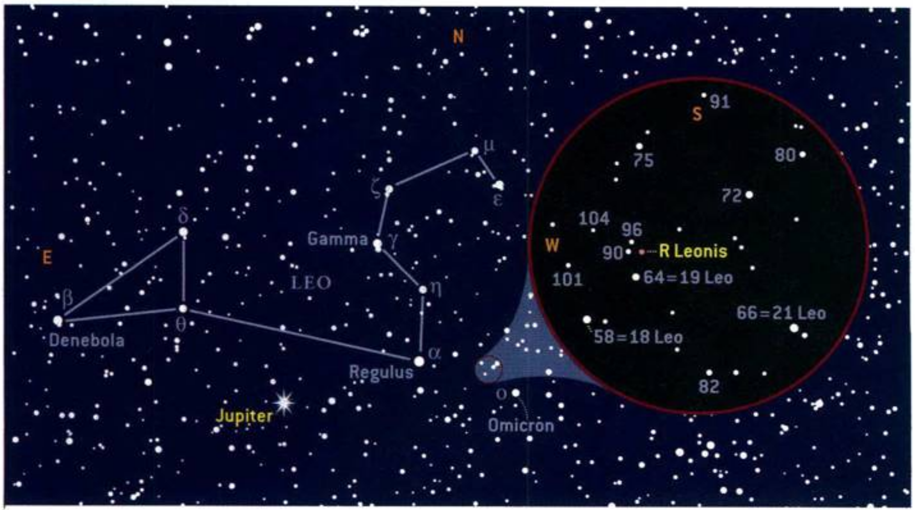
In like a lion

April's arrival signals the departure of Orion and his entourage from our evening skies. Though not as visually dramatic as Orion (what constellation could be?), Leo the Lion is still a noble sight. Arranged like a backward question mark and punctuated by the first-magnitude star Regulus, this "sickle" is accompanied to the east (left) by a triangle of bright stars. We view the lion from the side; the sickle outlines his head and front body, while the triangle forms his hindquarters. Fainter stars below these two asterisms create the lion's paws. With a little imagination, it's not hard to picture the "king of beasts" watching over his heavenly domain.

In November, eyes around the world gaze toward the sickle because it is the area from where the Leonid meteors radiate. But there's more to these stars than a famous meteor shower. Regulus, located at the base of the sickle (the period on the "question mark"), barely makes the grade as a first-magnitude star. At magnitude 1.35, Regulus is the 21st brightest star in the night sky and the last star bright enough to be called "first magnitude."

Another star near the sickle is celebrated for *changing* brightness. The star is R Leonis, an example of a Mira-type star, or a long-period variable. Variable stars in this category are old red giants whose unstable cores cause their outer layers to swell and contract in cycles that last from several months to several years. The result is a brightness change of more than three magnitudes. At its brightest, R Leonis shines at about 6th magnitude — barely visible to the unaided eye in dark skies. At minimum, it's a 10th-magnitude object — beyond the grasp of standard binoculars.

R Leonis was the first variable star I studied. An entry in my notebook, dated March 17, 1970, documents my quest to find the star after reading about it in an amateur astronomy handbook. With a 3-inch reflector, I scanned the area between Regulus and Omicron (O) Leonis and, right next to stars 18 and 19 Leonis, found a reddish star of about 6th magnitude. I carefully sketched the field, and a week later, I confirmed the sighting. I rechecked R Leonis during the ensuing months, noting a change in brightness.



R LEONIS can be located using this finder chart. Orient yourself by facing north. Tilt your head back so south is at the top of your view. The inset shows the telescope-inverted view. ASTRONOMY: ROEN KELLY

Inspired by the experience, I joined the American Association of Variable Star Observers (AAVSO) and have been a "gung-ho" variable star observer ever since.

Because it's bright and relatively easy to locate, R Leonis is a fine "beginner's variable." Use the finder chart on this page to help locate it. Work with a low-power eyepiece — one that produces a field at least one degree (two Moon diameters) across. Make observations about once a week. Predictions place R Leonis near minimum brightness during March and April, so expect it to resemble the two 9th-magnitude stars with which it forms a triangle.

Also in the sickle is the beautiful double star Gamma (γ) Leonis. This binary has an angular separation of just 4.5 arcseconds. One arcsecond is 1/3,600 of a degree, or the apparent width of a penny from 2.5 miles away, so you'll need a magnifying power of 100x to make a comfortable split. Both components are bright (magnitudes 2.6 and 3.8) and topaz yellow in color.

We can't leave the sickle without paying our respects to that bright "star" (Jupiter) shining nearby. It's appropriate that the "king of the planets" should be visiting the "king of beasts" at this time. A 2-inch telescope will show (at 75x to 100x) cloud belts traversing Jupiter's slightly flattened disk. Its four bright moons are a visual delight. As an added treat, the Moon drifts through this area on the first two evenings of April and again at month's end.

For more information on variable stars, see the AAVSO web site: *www.aavso.org*.

Next month: Galaxy hunting near the Big Dipper. Clear skies.

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BY WILLIAM SCHOMAKER

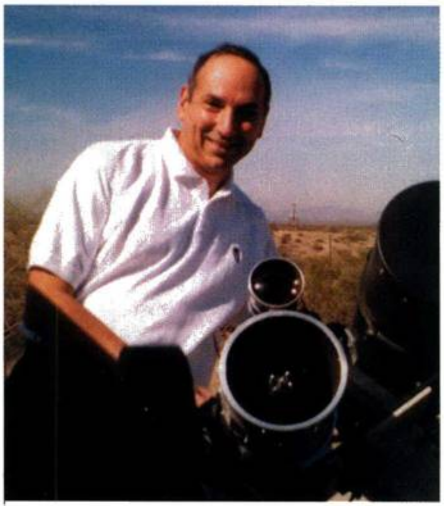
David Levy

A consummate comet hunter, father, grandfather, radio host, Emmy-winning writer, and lecturer, David Levy is a real-life oxymoron. He's the quintessential professional amateur astronomer and arguably astronomy's most famous regular guy. ☾ With fanfare typically reserved for celebrity weddings or political scandal, Levy's name exploded onto the global scene in 1994. That summer, the world was glued to the TV in shock and awe as his namesake discovery, Comet Shoemaker-Levy 9, delivered its salvo into Jupiter's atmosphere. The collision made history and catapulted Levy to stardom. Now, ten years later, he is seeking to add a 22nd notch to his comet-discovery bedpost. But a new breed of automated comet-searching science programs, with names like LINEAR and NEAT, is forcing him to share the sky's limited quarry. In the meantime, Levy is working on a Ph.D. dissertation about interpretations of celestial events in early modern English literature at the Hebrew University in Jerusalem.

When did your experiences with astronomy evolve from passing interest into passion?

My first formal observing session was a partial eclipse of the Sun in 1959. There was something about watching the Moon pass in front of the Sun that was just extraordinary to me. But astronomy didn't become a real passion until 1965, when I was finishing up the Messier list and I decided to search for comets.

[The passion for astronomy] came suddenly while walking to high school for my French oral examinations. Growing up in Montreal, we had to be fluent in French. I knew one of the questions was going to be: What are you going to do as a career? I had to come up with something that would be translatable into French, but it also had to be something that was believable. I was thinking about Comet Ikeya-Seki, which was coming in at the time, and I said to myself, "I want to search for comets," and it suddenly hit me that's what I wanted to do. I remember the instructor asking the question and I said, "Je veux decouvrir une comète." He looked at me and, in English, asked, "How the heck do you expect to make any money doing that?"



DAVID LEVY made a profession out of his passion. Even so, he continues to be an enthusiastic student of astronomy. WENDY WALLACH-LEVY

I read that you were once secretive about searching for comets. Why?

When I started comet hunting in 1965, I decided to tell only my closest friends. That changed when I moved to Arizona in 1979 because I moved for the specific purpose of getting the clear skies necessary for discovering a comet. I felt that I didn't want to tell people about what I was going to do. My dad used to say, "Don't tell people what you're going to do. Just do it, and then tell them about what you've done." I don't even think my parents knew I was serious about comet hunting until I found my first comet [in 1984].

Has modern science hijacked the mystique from celestial events like passing comets?

Yes! Next question. [*laughs*]

Most of the newly discovered comets are now LINEAR and NEAT comets. Some people want to stop naming comets and asteroids, which would sadly remove one of the few completely human aspects of astronomy remaining.

What do you see as the role of hobbyists and amateurs in astronomy today?

To have fun and appreciate the beauty and incredible nature of the night sky. That said, if an amateur desires to make a contribution that will help the march of our understanding of astronomy by doing variable-star research, or follow-up observations of newly discovered asteroids, or any one of a million things that one can do, then that's a wonderful bonus.

[The famous deep-sky observer] Walter Scott Houston once said the greatest thing about being an amateur is that you don't have to report to anybody and no one expects you to succeed. And that puts the amateur in a very powerful position.

How can our readers learn more about becoming successful comet hunters?

Run out to the nearest bookstore and order my latest book, *David Levy's Guide to Observing and Discovering Comets*. It contains information on how to discover and observe comets, and how I do it.

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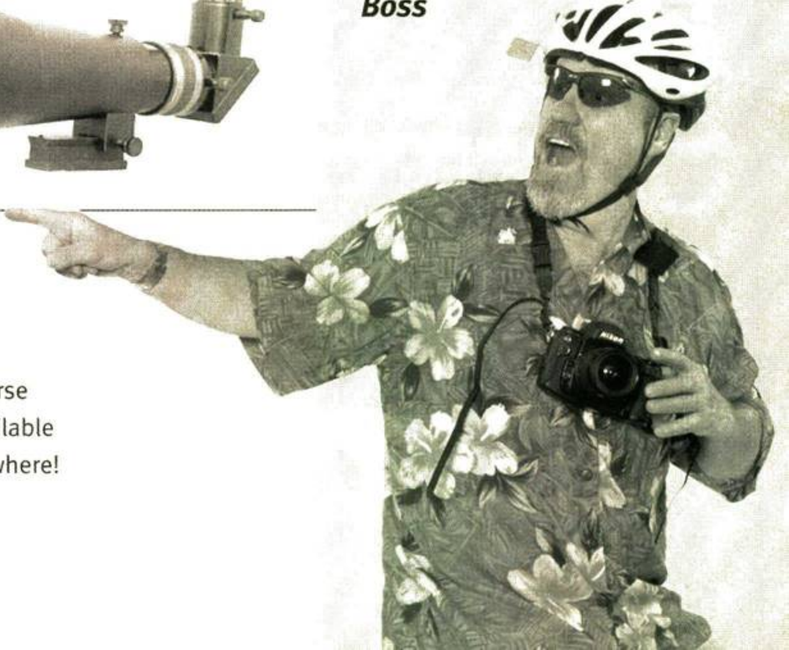

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Losmandy G-11

Granted, you usually won't find the $84,150 Takahashi computerized mount in stock, but we *do* keep a good inventory of those mounts priced under $10,000. Here's a *partial* list of the mounts we had in stock or readily available as this was written:

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Meade Starfinder, w/pier, 1-axis drive	1995^{00}
LXD650, metal tripod, #1697 go-to	2595^{00}
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Questar 7" Fork, no tripod, 1-axis drive	\$6495^{00}
Software Bisque Paramount ME, no pier or tripod, 2-axis go-to drive	10,000^{00}
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NJP/TGT, wood tripod, Temma go-to	6949^{00}
NJP/P, pier, 2-axis drive	6049^{00}
NJP/PGT, pier, Temma go-to	6949^{00}
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GPW, wood tripod, no drive	980^{00}
GPDX, metal tripod, no drive	1220^{00}
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NP-101, 4" f/5.4 apo	3595^{00}

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This narrow passband <0.8 Ångstrom hydrogen alpha solar filter was named a *Sky & Telescope* Hot Product. It will double the use you get out of your scope by letting you observe our nearest star during the day. Put it on your telescope (using an optional adapter plate) and you'll see highly detailed and ever-changing views of solar flares and prominences (not just sunspots, as with conventional solar filters). It works well with most scopes but its 10mm blocking filter (mounted in the supplied 1.25" diagonal shown) is particularly well-suited to refractors under 1000mm in focal length.

Any 1.25" eyepiece will work, but Coronado CEMAX 12mm, 18mm, and 25mm eyepieces are optimized for high contrast solar viewing.

Denkmeier Binoviewers are optimized for your scope.

When you use both eyes to observe through a **Denkmeier Binoviewer**, you can see up to 40% more detail than you can when looking through a single eyepiece. Your views of the planets, Moon, and deep space objects become almost three-dimensional.

Whether you have a refractor, reflector, or SCT, there's a version of the Denkmeier Binoviewer with optics optimized to give you peak performance with your particular telescope type. Prices start at $599.

Sell your used telescopes and accessories quickly *for free* by using the no-charge classified ads at www.astrofieds.com

Our *38* light pollution filters make bright skies dark.

If city lights wash out your view of the skies, *get rid* of the pollution with one of the 38 different light pollution reduction filters we stock.

We have two **Celestron** broadband filters. One is designed for 1.25" eyepieces; one for Schmidt-Cassegrain (SCT) rear cells.

We have 13 **Lumicon** Deep Sky broadband, UHC narrowband, and H-Beta and Oxygen III line band filters for use in 1.25" and 2" eyepieces, as well as on SCT rear cells.

We have six **Meade** broadband, narrowband, and Oxygen III filters in 1.25" eyepiece and SCT rear cell versions.

We have four **Sirius** contrast enhancement and nebula filters for 1.25" and 2" eyepieces, plus a unique 1.25" *variable* nebula filter.

We have four **TeleVue** Bandmate NebuStar UHC-type narrowband and Oxygen III filters in both 1.25" and 2" eyepiece versions.

We have eight **Thousand Oaks** broadband, narrowband, Oxygen III, and H-Beta filters in both 1.25" and 2" eyepiece versions.

Some dealers carry a few filters. We carry 38. We have one that's right for you.

There's nothing mysterious about *this* Sphinx!

The **Vixen Sphinx** telescopes and mounts take the mystery out of go-to astronomy. You don't have to know Messier, NGC, or IC numbers to have your scope find deep sky objects.

Simply move the crosshair cursor over the object displayed on the Star Book hand control's 4096-color LCD star chart screen. Push a button and the Sphinx mount moves to that object. Zoom-In/Out buttons for the star chart display also control the motor speed. As you zoom in on an object displayed on the screen, the motor speed automatically slows for more accurate control. Zoom out and the motor speed increases to cover large distances quickly.

Vixen Star Book hand control showing star chart display

The Star Book control's 4MB flash ROM memory can be updated from the Internet to keep you current with the heavens. And the easy-to-use Star Book controller can be used as a stand-alone star atlas to learn the skies anywhere, anytime.

The Sphinx go-to mount with Star Book controller is available separately for use with your own optics. It is also available in ultra-premium Vixen telescope packages that range from an 3.1" f/5 refractor on a supremely portable tabletop go-to mount to big 8" reflectors and catadioptrics on full length field tripods.

FL80SWT-SXW
3.1" f/8 fluorite apo Vixen refractor on Sphinx go-to mount
$3910

You'll find full Vixen Sphinx details and prices on our **www.astronomics.com** website.

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Meade ETX Maks now come with tripod and Autostar!

5" ETX-125EC
$995, complete

Best-selling **Meade ETX Maksutov-Cassegrains** just got even better. They now include a heavy duty tripod and Autostar computer for less than the former cost of the same components bought separately. Prices start at only $595 for a full-featured go-to telescope with everything you need to start observing as soon as you get it. Each comes with an adjustable height tripod, Autostar computer with 30,223 star and object memory, 26mm Super Plössl eyepiece, and more. Optional UHTC (Ultra High Transmission Coatings) optics are available for images up to 20% brighter than standard optics so you can see 20% more of the Universe.

Authorized Meade Dealer

Best-selling Meade ETX Maksutovs, now better than ever – and they're in stock!

Get a go-to *now.* We'll ship your Celestron from stock.

Celestron Advanced Series scopes put multicoated optics on an easy-to-use go-to mount. From a 5" SCT (with optics so good that NASA flies them on the Space Shuttle) to a 10" reflector, there's a Celestron go-to that's right for you and your budget. You can even get state-of-the-art Starbright XLT multicoatings as an option on the bigger SCTs. Scopes include:

an 8" Newtonian reflector	**$949^{00}**
a 6" achromatic refractor	**999^{00}**
a 5" Schmidt-Cassegrain	**1099^{00}**
a 10" Newtonian reflector	**1149^{00}**
an 8" Schmidt-Cassegrain	**1299^{00}**
an 8" SCT with XLT coatings	**1424^{00}**
a 9¼" Schmidt-Cassegrain	**1699^{00}**
and a 9¼" SCT with XLT coatings	**1874^{00}**

Each has a heavy duty adjustable height tripod with rigid 2" diameter steel legs instead of the lighter aluminum legs used in other scopes. Their go-to computers have a data-base of 45,000+ stars and objects they can find for you. High speed dual-axis DC servo motors are standard. The list of features goes on and on – at prices that start as low as $949. These Celestrons ship from our stock. There's no waiting for a manufacturer to dropship your scope.

Celestron C 8 S-GT 8" go-to

$1299
($1424 with optional XLT coatings)

CELESTRON

Eyepiece cases start at only $2^{49}!

These bolt-type containers keep your eyepieces free from dew and dust. Foam inserts cradle the eyepieces to protect against accidents. Our website at **www.astronomics.com** lists which specific eyepieces fit into which containers.

42mm x 60mm holds most Celestron Omni and E-Lux, Meade Series 3000, and TeleVue Plössls.	**$2^{49}**
52mm x 80mm holds TeleVue Radians, Nagler Type 6, most Barlows, large Celestron Ultimas, etc.	**$3^{49}**
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Do Celestron CGE go-to scopes have the perfect mount for astrophotography?

Astrophotography with a fork-mounted go-to Schmidt-Cassegrain has its drawbacks. You can't use its altazimuth mount to take long exposure deep space photos without adding a costly equatorial wedge or field derotator. Use a wedge and you can't image near the celestial pole or the southern horizon, and tube vibrations can become a problem. Use a field derotator and you lose periodic error correction and can't image near the zenith. In larger apertures, fork-mounted scopes usually require two people to set up.

Celestron CGE German equatorial go-to scopes solve these problems. Even the big 14" CGE1400 can be set up by only one person. The CGE mount can reach all parts of the sky, without adding a costly wedge or field derotator. And German mounts are known for being virtually vibration-free.

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$4150

Celestron CGE1100

Only $999 for a 5" GPS-ready Celestron SCT!

The **Celestron NexStar 5i** is the *only* 5" telescope to have a fully automatic GPS go-to computer available as an option. No other 5" scope has GPS! The NexStar 5i has a computer hand control with a 45,000+ star and object database, tripod, finder, eyepiece – everything you need to start observing immediately!

Multicoated optics are *standard equipment* with the Celestron NexStar 5i, not an option as with other scopes. NASA uses Celestron 5" multicoated optics on the Space Shuttle. Don't your eyes deserve the same premium image quality? **$999**

the Nexstar 5i is shown with optional photography accessories

NexStar 5i

CELESTRON

Only $1299 for an 8" Celestron NexStar 8i GPS-ready go-to SCT!

NexStar 8i

$1299

The $1299 **Celestron NexStar 8i** costs hundreds less than other comparably-equipped 8" go-to scopes. You can start observing with it as soon as you take it out of the box. Its computer has a library of 45,000+ stars and objects it can find for you. It has a tripod, red dot finder, and eyepiece. Starbright multicoatings are standard equipment, not an optional extra. If you want GPS (an unavailable option on other scopes), it's only $199. The NexStar 8i is enough scope to keep you observing for the rest of your life, at a price that leaves most other scopes behind.

the Nexstar 8i is shown with all standard accessories

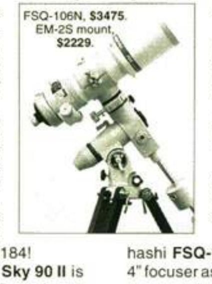
The Takahashi premium apo optics sale!

If there's anything better than the superb optical perfomance of a **Takahashi** *fluorite apochromatic* refractor, it's the speed at which you can get Takahashi optics from our stock.

And what makes the fast delivery even better are the special sale prices on Takahashi's best-selling optical tubes. You can save as much as $2334 if you act now!

The 3.1" **FS-78** fluorite doublet optical tube is on sale for **$1195!** It's regularly $1379, so you save $184!

Takahashi's unique 90mm f/5.6 **Sky 90 II** is on sale for **$1849!** Regularly $2279, you save $430! With dew shield retracted, this fluorite apo is less than 14" long! *Sky & Telescope* called it "an ideal travelscope for mobile observers, providing maximum performance at minimum size."



FSQ-106N, **$3475.**
EM-2S mount, **$2229.**

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Finally, the big 6" **FS-152** fluorite doublet optical tube is on sale for **only $6995**! Regularly $9329, you save $2334!

We also stock the 22" long Takahashi **FSQ-106N** 4-element f/5 4" *dual fluorite* 4" focuser astrograph apo refractor OTA, shown on an optional mount to the left.

If you want a premium apo refractor at a money-saving sale price, and you want it without a lo-o-o-ng wait, the refractor you want is a Takahashi from ***astronomics***.

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A NEUTRON STAR IS JETTING MATERIAL at nearly light-speed, say astronomers studying the X-ray source Circinus X-1. Astronomers had thought only a black hole's environment could produce such extreme acceleration.

news 04

Read all about it: Stardust flies past Comet Wild 2, the first double pulsar ever found, where spiral galaxies go, and a record-breaking quasar mirage.

ASTROBIOLOGY

Galactic habitable zone: the Milky Way's "ring of life"

A team of astronomers has identified the Galactic Habitable Zone (GHZ) — the part of the Milky Way where life can exist. It's a ring-shaped region in the galactic plane, about 25,000 light-years out from the galactic center — and it includes about one-tenth of the galaxy's stars.

Charles Lineweaver (University of New South Wales) and colleagues at Swinburne University modeled the Milky Way's chemical and dynamical evolution.

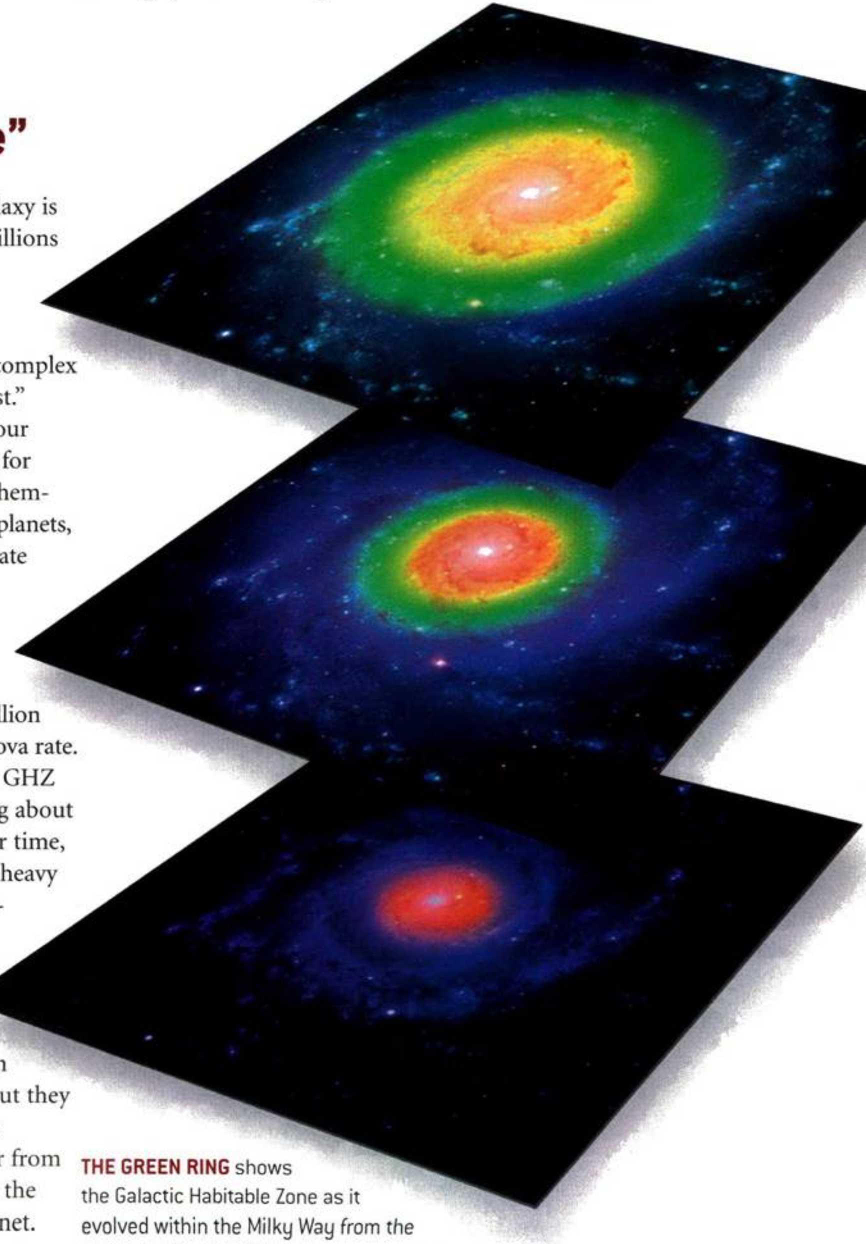
"The Milky Way Galaxy is home to hundreds of billions of stars," Lineweaver explains, "What we did for the first time was to quantify where complex life is most likely to exist."

The GHZ contains four important prerequisites for complex life: the right chemistry to form terrestrial planets, lots of stars with moderate amounts of heavy elements, an interstellar environment that has remained calm and stable for several billion years, and a low supernova rate.

The team found the GHZ formed as a narrow ring about 8 billion years ago. Over time, the GHZ broadened as heavy elements formed in distant regions of the Milky Way.

The team was reassured to see that the solar system falls within the GHZ. But they also noted that Earth is younger and lies farther from the galactic center than the average life-bearing planet.

— ANNIE HUGHES



THE GREEN RING shows the Galactic Habitable Zone as it evolved within the Milky Way from the beginning [bottom] to now. Y. FENNER/GEMINIA OBS.

24 Stardust meets Comet Wild 2; heads for Earth

25 Getting people to Mars via the Moon

26 Probing the power of galactic winds

28 Supersized superstar

ANACORTES

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Tele Vue 60 APO

Tele Vue NP 101

Tele Vue Telescopes

Stunning performance and exceptional consistency

Tele Vue telescopes will provide you with a lifetime of observing experiences. The quality of each scope is certain to impress. One look tells you that these are designed for performance. One look tells you to choose Tele Vue.

The NP 101 represents Tele Vue's closest realization yet of the "ideal" multi-purpose/visual telescope. Its snap-to-focus and extremely sharp flat-field are sure to take your breath away. It is also the best and toughest test platform to showcase all of Tele Vue's new eyepiece introductions.

The Tele Vue 60's small size makes it ideal for amateur astronomers on the go. It's a super-finder, day/night scope with great telephoto and imaging capability for digital cameras.

Tele Vue 60 APO	$795
Tele Vue NP 101	$3,595

Meade LX200GPS Family of Telescopes

Serious telescopes for the world
Meade LX200GPS Schmidt-Cassegrains

The reasons for the overwhelming acceptance of LX200GPS telescopes are clear: advanced technology at the very leading edge of telescope design; the patented Autostar control system; legendary diffraction-limited optical systems with optionally available Ultra-High Transmission Coatings (UHTC); and uncanny, 1-arcminute, high-precision pointing in the GO TO mode that positions objects on even the smallest CCD chips.

Little wonder that by any comparison, LX200GPS Schmidt-Cassegrains are the telescopes chosen by advanced amateurs worldwide for their visual, photographic and CCD applications.

Meade 8" LX200GPS-Smart Mount Technology (SMT) with UHTC Coatings	$2,370
Meade 10" LX200GPS-Smart Mount Technology (SMT) with UHTC Coatings	$2,980

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Tele Vue Eyepieces

Your telescope is only as good as your eyepiece. Fortunately, Tele Vue offers a broad range of Naglers, Radians and Panoptics to ensure that your viewing experience is never compromised.

Tele Vue Nagler Zoom eyepiece 2mm - 4mm	$395
Tele Vue 11mm Nagler Type 6	$280
Tele Vue 3mm Radian	$240
Tele Vue 4mm Radian	$240
Tele Vue 5mm Radian	$240
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Tele Vue 8mm Radian	$240
Tele Vue 10mm Radian	$240
Tele Vue 12mm Radian	$240
Tele Vue 14mm Radian	$240
Tele Vue 18mm Radian	$240
Tele Vue 24mm Panoptic	$240
Tele Vue Bino Vue Binocular Viewer	$1,030

Coronado MaxScope 40mm

MaxScope's 40mm Solar Telescope is specifically designed to optimize the performance of the SOLARMAX40 filter, and for limited time, the price has been optimized too. Act now, and you can save $500 on the MaxScope 40mm Telescope Package, which includes a carrying case, mounting rings and TMAX tuner. The MaxScope features a special H-Alpha doublet lens designed by Dick Buchroeder (including optimized anti-ghosting) and superb multi-layer anti-reflection coatings on all surfaces. The result? Diffraction-limited, extremely high-contrast performance.

Coronado Instruments MaxScope 40mm BF/5 Solar Telescope Package	$1,595

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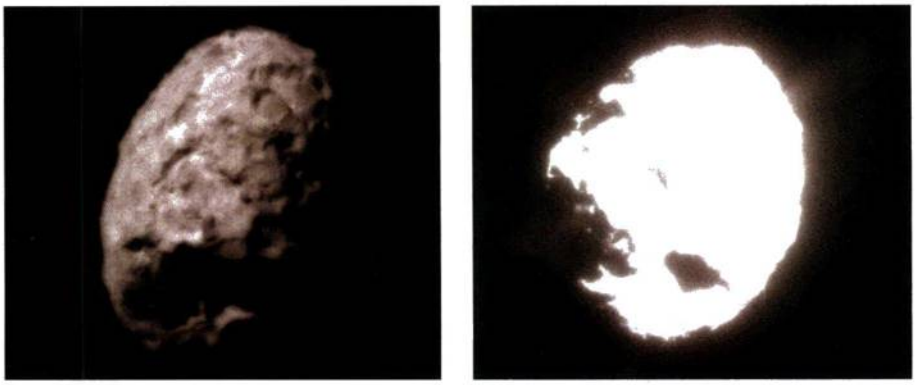
COMETS

Stardust collects bits of Comet Wild 2



PITS AND POCKS cover the surface of Comet Wild 2 (left), while image processing reveals faint jets spurting from its nucleus (right). The pits most probably form as ice in the nucleus evaporates. NASA/JPL

ZOOMING PAST COMET WILD 2, the Stardust spacecraft collected dust and gas samples while imaging the comet's nucleus in unprecedented detail. NASA/JPL

The Spirit rover's landing on Mars got more publicity. But Stardust's successful flight within 143 miles (230 km) of the nucleus of Comet Wild 2 a day earlier is probably equally important. Moreover, Stardust is arguably an even more significant historic landmark. This mission begins a new era in space exploration, being the first to return samples to Earth from the solar system beyond the Moon.

During its flyby, Stardust scooped at least one milligram of dust particles from the comet's coma. The super-low-density aerogel probably also absorbed a significant amount of frozen low-temperature gases and organic compounds from the coma. All of this will be dropped off in a return capsule when Stardust flies past Earth on January 15, 2006.

Even such a tiny amount of cometary material — some 1,200 or more specks of dust — can provide unprecedented information on the physical and chemical conditions in the outermost parts of the solar system during its formation. Before the comet encounter, Stardust used the other side of its sample collector to gather at least a hundred even tinier particles of interstellar dust streaming through the solar system.

The flyby was perhaps as risky as Spirit's landing. Engineers found a trajectory that allowed the spacecraft to fly by the comet at only 3.8 miles (6.1 km) per second, slow enough that most of each particle would be unmelted by friction as it plowed into the aerogel during capture. By chance, Wild 2 arrived in the inner solar system only 30 years ago after a close flyby of Jupiter. Thus, it has been little modified by exposure to the heat of the Sun. But even this slow speed meant that, for 12 minutes around closest approach, the spacecraft was machine-gunned by a dozen particles the size of small bullets but far faster. Stardust ran into one unexpected and intense stream of dust particles — apparently jetted from the nucleus — several minutes after closest approach.

However, Stardust kept its navigation camera pointed at the comet's nucleus throughout the flyby. It returned 72 pictures of the nucleus (see selection below), the sharpest ever taken. Wild 2's 3-mile (5-km) nucleus was surprisingly round. Comet nuclei that have undergone longer exposure to the Sun seem to have their equatorial regions vaporized, eroding them into thinner cylindrical shapes.

Wild 2's nucleus is covered by huge depressions up to 1,000 feet wide and 400 feet deep. These aren't impact craters — they're too deep, with flat bottoms and sharply vertical walls. It's likely that, on this fresh comet, we're seeing the start of the process by which the Sun erodes a comet. On Wild 2's first pass by the Sun, the surface ice vaporized, leaving a black crust of dust and tarry organics. On its next pass, the ice still vaporized, but it could escape only by bursting through vents in the crust. This made the crust at the edges of the vents collapse into the cavity, leaving flat-bottomed holes.

Since then, ice has been vaporizing mostly from the vertical walls, where the crust crumbles and slumps to expose more fresh ice. Steadily, each hole widens and some merge into bigger holes with scalloped edges. Eventually the process will strip away most of the comet's surface, leaving only a few isolated "mesas" whose vertical walls are still eroding.

If the process is logical in retrospect, it still surprised Stardust's scientists. More surprises will doubtless turn up when the comet's material finally returns to Earth and is analyzed — which is precisely why the mission was launched.

"It's great when nature willingly cooperates to tell us her secrets," says chief investigator Don Brownlee (University of Washington). — **BRUCE MOOMAW**

THE HUBBLE SPACE TELESCOPE'S mission will end sometime in the next several years, due to failing batteries and gyroscopes. NASA has decided not to fly a scheduled fourth servicing mission, citing the shuttle's riskiness.

STELLAR ASTROPHYSICS

Double pulsar found: will test extreme physics

A binary star system 2,000 light-years away, reported to contain a pulsar and a neutron star (see News, March 2003), actually has *two* pulsars, the first such pair found.

A team led by Andrew Lyne (University of Manchester) made the discovery; it was published in *Science Express* on January 8, 2004. The pulsars, designated PSR J0737–3039A and B, have a 2.4-hour orbit nearly edge-on to Earth. This means the B pulsar eclipses A periodically.

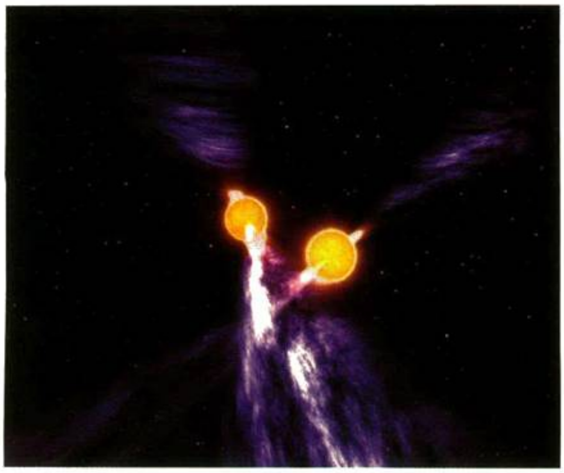
Pulsars are rotating neutron stars that beam radiation. If the beam passes across Earth, we see a flash that marks the star as a pulsar. In this case, the newly discovered B pulsar flashes once every 2.8 seconds, while the A pulsar spins 44 times per second.

The more massive star in the pair evolved and went supernova, creating the A pulsar. As the B star became a red giant, the A pulsar began to pull gas from it. This sped up the A star's rotation. Finally, the B star also exploded, making a second pulsar.

The team expects to see orbital decay as the pulsars radiate gravity waves as relativity predicts; theory suggests they will spiral into each other about 85 million years from now.

Study of the eclipses also shows that A's pulsar beam is blasting B's magnetosphere. This will give insights on pulsar beams and magnetospheres.

— ROBERT BURNHAM



A VIOLENT HISTORY LINKS the two stars in the pulsar PSR J0737–3039. The more massive star in the original binary pair exploded as a supernova, leaving a pulsar remnant. Then the second star exploded, creating the second pulsar. JOHN ROWE ANIMATION

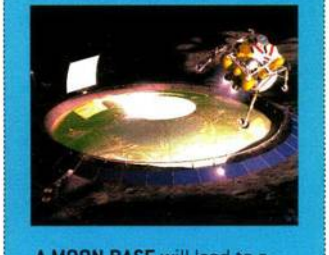
SPACE EXPLORATION

To Mars, via the Moon

A manned base on the Moon will be built by 2013 in preparation for human flights to Mars and to near-Earth asteroids, beginning in the 2020s, according to a new space initiative proposed by U.S. president George W. Bush in January 2004.

A lunar base, perhaps at the Moon's south pole, would let NASA test technologies and procedures for a Mars expedition, which would last at least a year.

The plan also calls for retiring the space shuttles once the space station is finished. A new spacecraft to ferry crews to both the station and the Moon will be developed. — R. B.



A MOON BASE will lead to a manned Mars mission in NASA's new plans. P. RAWLINGS/NASA

ASTROPHYSICS

Is this the smallest black hole known?

Two astronomers believe they have found the smallest-mass black hole yet discovered. It is part of a binary star system that emits bursts of X rays from time to time.

Writing in the *Astrophysical Journal* (December 20, 2003), Dawn Gelino (U.C.–San Diego) and Thomas Harrison (New Mexico State University) note that the X-ray transient J0422+32 contains an M-type companion star and an unseen primary around which the companion star is orbiting with a 5.1-hour period.

After observing the system carefully at multiple wavelengths, Gelino and Harrison conclude that the orbital inclination of the pair is more nearly face-on than previous studies have shown. This has the effect of increasing the likely mass of the primary star.

The new results give it a mass of 3.97 solar masses — too large for a neutron star, but just enough for a black hole. **— R. B.**

STELLAR ASTROPHYSICS

Supernova survivor-star found

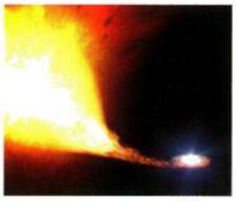
A massive star has been found that survived the explosion of its companion as a supernova, the first such stellar survivor to be detected.

A group of astronomers led by Justyn Maund (Cambridge Univ.) used the Hubble Space Telescope and the 10-meter Keck telescope to examine the aftermath of supernova 1993J ten years after it exploded. (The supernova occurred in spiral galaxy M81.)

Writing in *Nature* (January 8, 2004), they report seeing the massive companion star to the supergiant that exploded in 1993.

The team's finding also explains puzzling, older observations by showing that over the 250 years before the supernova, the companion star had ripped about 10 solar masses of gas from the red supergiant. Thus, the exploding star was already partly torn apart when it went supernova.

The team hopes to see this former supergiant emerge as a neutron star or black hole in years to come. **— R. B.**

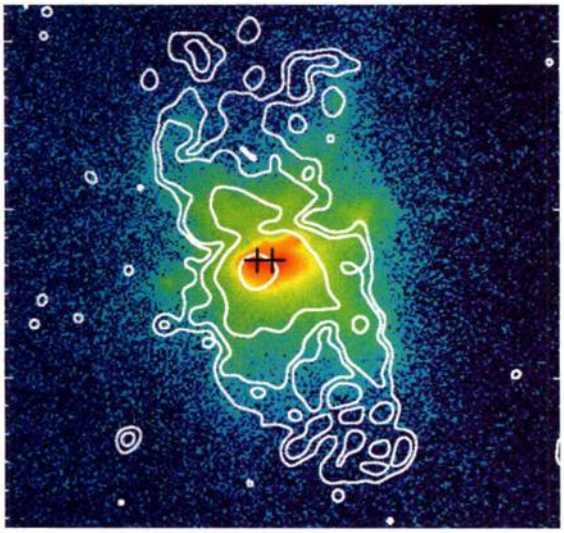


ABOUT TO BLOW, a supergiant star [left] feeds a companion [right] that will survive when the giant goes supernova. ESA ART

THE SUN HAS A (NEAR) TWIN in the naked-eye star 18 Scorpii, 46 light-years away. 18 Sco has about 1 percent more mass than the Sun and the same surface temperature. It even has a starspot cycle lasting 9 to 13 years.

EXTRAGALACTIC ASTRONOMY

Where galactic winds blow



GALACTIC WINDS stream from starburst galaxy NGC 1482. The colors show the densities of ionized nitrogen, and the contours map X-ray emission seen by the Chandra Observatory. CXC

Astronomers know that galaxies swirl in seas of invisible dark matter, detectable only by its gravitational tug. Now comes the idea that galaxies also drape themselves in vast galactic winds — streams of charged particles blasted into intergalactic space by swarms of unstable young stars, supernovae, and supermassive black holes. Winds that fail to escape a galaxy's gravity may fall back to seed new, metal-rich stars and planetary systems.

University of Maryland astronomer Sylvain Veilleux and his colleagues built a highly sensitive filter to detect faint light from ionized gas on the outskirts of galaxies. They mapped ten nearby galaxies using the 3.9-meter Anglo-Australian Telescope and the orbiting Chandra X-ray Observatory. Six of the galaxies sported galactic winds, loops, and filaments stretching 65,000 to 650,000 light-years.

"We're seeing the tip of the iceberg," says team member Joss Bland-Hawthorn at the Anglo-American Observatory. "I bet a lot of the energy is invisible to us and these winds are in fact far more violent, and extend even further, than we think."

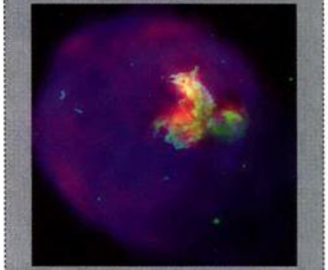
Large-scale winds have important implications for the evolution of galaxies, says Veilleux. Some material may escape, but much of it, rich in heavier elements forged in supernovae, rains back into the galaxies. There it can speed the formation of new stars, likely candidates for planetary systems. — **ROBERT ADLER**

STELLAR ASTROPHYSICS

SN blows X-ray bubble

Once upon a time, a big star exploded as a supernova in the Large Magellanic Cloud, blasting a shock wave into space. As the shock slammed into gas and dust shed by the star earlier, it heated them to 10 million degrees Celsius, making them shine brightly in X rays.

NASA's Chandra X-ray Observatory imaged the supernova remnant, now 2,000 to 5,000 years old. The brighter edges in the image trace high-velocity "bullets" of debris from the supernova. — R. B.



A HAZY CLOUD marks X-ray-emitting gas heated by a supernova shock wave. CXC

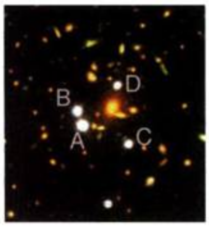
EXTRAGALACTIC ASTRONOMY

Record-breaking quasar mirage

A newly found gravitational lens is projecting the light of a quasar in four directions with the widest spread yet seen. The quasar lies more than 10 billion light-years away, parked behind a massive cluster of galaxies.

A group led by Naoisha Inada (University of Tokyo) pored over more than 30,000 quasar images in the Sloan Digital Sky Survey to locate the object, J1004+4112. The results appear in *Nature* (December 18/25, 2003).

The images lie 14.62 arcseconds apart, a spread attributed to dark matter in the lensing galaxies, which lie 6.2 billion light-years from Earth. — **ANDREW FAZEKAS**

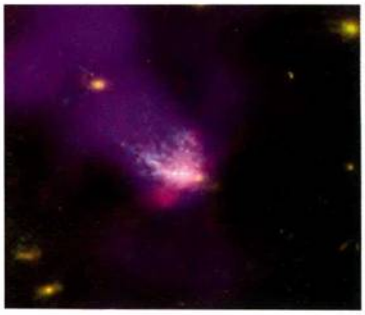


QUASAR FOURPLEX (A–D) is really a single quasar multiplied by a gravitational lens. SDSS

EXTRAGALACTIC ASTRONOMY

Where have all the spirals gone?

A spiral galaxy named C153 probably once resembled the Milky Way. But C153 now trails streamers of hot gas 200,000 light-years long after plunging through a distant cluster of galaxies.



PURPLE HAZE traces X rays from hot gas stripped out of a spiral galaxy, as seen by the Chandra Observatory. CXC

"It's a clear case of galaxy assault and battery," says William Keel (Univ. of Alabama), who led the team that found a violent collision with the cluster's superheated gas created the carnage.

C153 may exemplify how the universe destroys spiral galaxies. A rich galaxy cluster 5 billion years ago would have had many spirals. But today, spirals are exceedingly rare in the richest clusters. Why?

Possible answers include frequent mergers, tidal breakup, and as C153 shows, stripping of gas through collisions. — **RICH TALCOTT**

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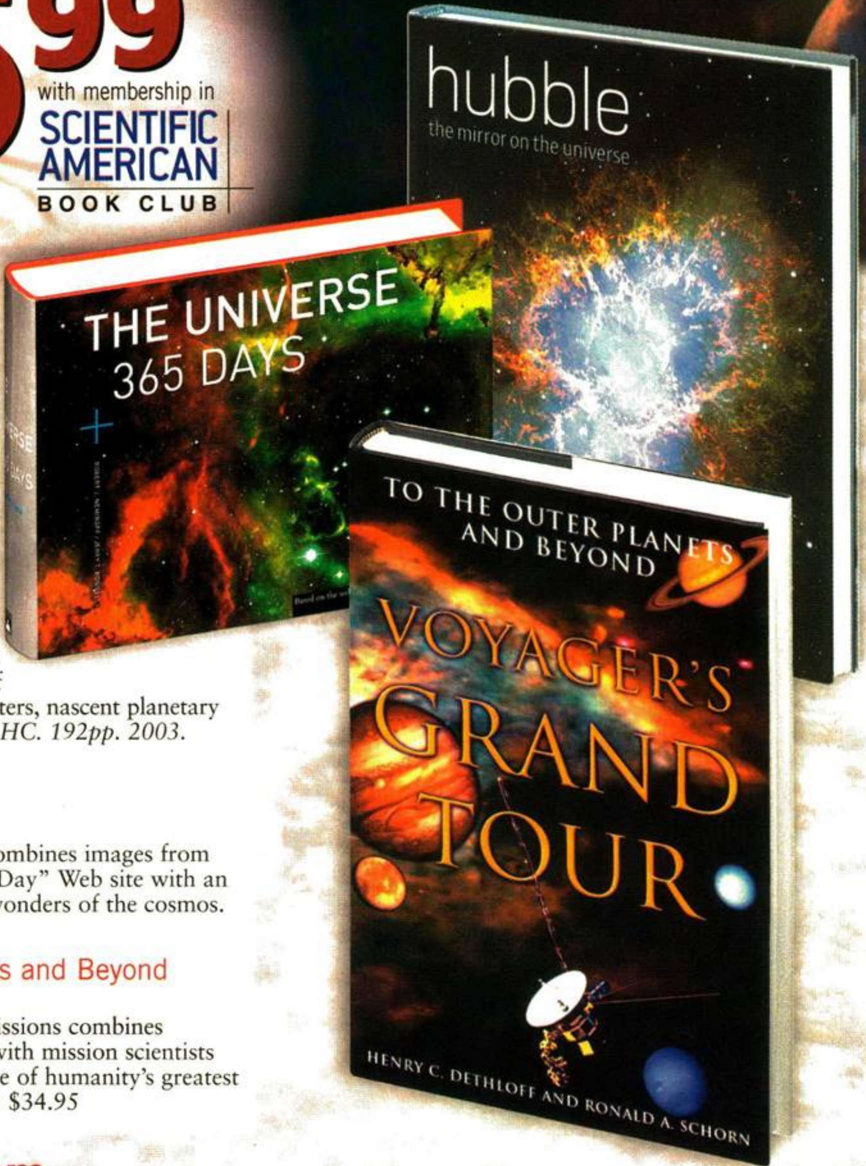
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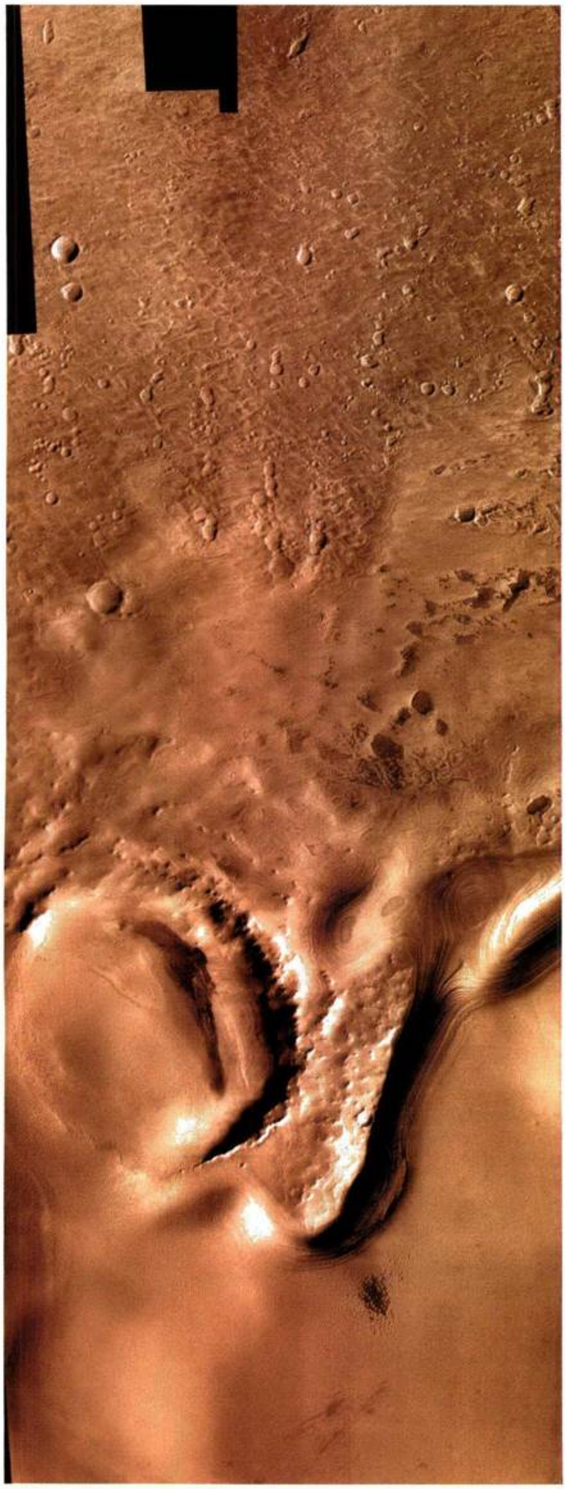
Astronomy April '04 E014/TS031/32

SMALL EXOPLANETS MAY NOT BE EARTHLIKE if they form far out from their star, where low temperatures will give them big, gaseous atmospheres. If the planets move inward, they may be easy to detect as the gases boil off.

Martian polar layers



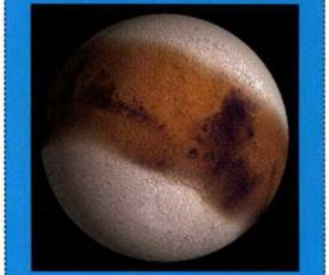
LAYERED DEPOSITS cover a cratered plain near the martian south pole. The ice cap's edge appears to be eroding poleward, exposing layers in the retreating cliff. NASA/JPL/ASU/IMAGE 20031210A

PLANETARY SCIENCE

Is Mars emerging from an ice age?

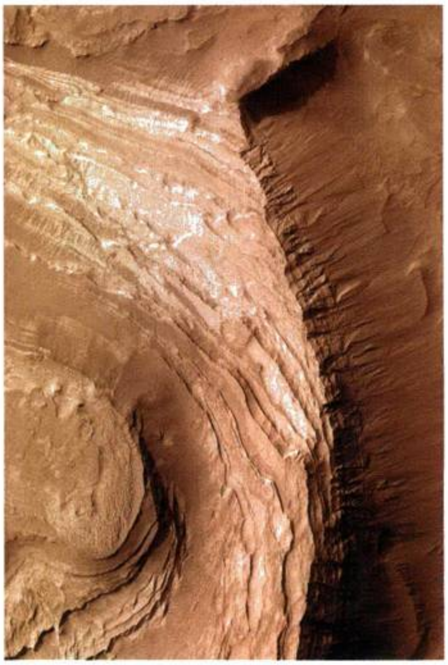
Present-day Mars shows features hinting it emerged from an ice age fairly recently, says a team of scientists led by James Head (Brown University) writing in *Nature* (December 18, 2003).

The team points to water (or ice) detected in the ground plus widespread deposits of dusty, water-rich material in both hemispheres from mid-latitudes to the poles. Such deposits could not form at present but could during an ice age, which the team suggests lasted from about 2.1 million to 400,000 years ago. — R. B.



A GREATER TILT could warm Mars's poles, moving water to lower latitudes. P. NEIVERT/BROWN UNIV.

MARS PHOTOJOURNAL



A RIDGE IN TERBY CRATER exposes layers of sedimentary outcrops. In total, the layers stack up several miles thick, indicating that deposition in this basin has a long history. Terby crater lies near 28° south and 285° west. The image, sunlit from the upper left, is about 1.9 miles (3 kilometers) wide. NASA/JPL/MALIN SPACE SCIENCE SYSTEMS/IMAGE R03-00753

STELLAR ASTROPHYSICS

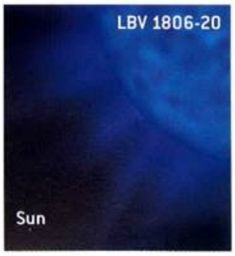
Supersize that superstar!

What appears to be the biggest, brightest star known has been discovered by a team of astronomers led by Steve Eikenberry (Univ. Florida). The star, designated LBV 1806–20, may shine 40 million times brighter than the Sun and is 150 times larger. It is visible only at infrared wavelengths and lies about 45,000 light-years away.

"The high-resolution data prove the object is not simply a cluster of lower-mass stars," says astronomer Don Figer (STScI). "But it could be a few stars in a tight orbit." Further observations should let the researchers measure the object's distance more precisely and confirm that it is a single star.

The astronomers used the 200-inch telescope on Palomar Mountain and the 4-meter telescope at Cerro Tololo in Chile.

Making a star that large is not easy, says Eikenberry. It may have formed when a supernova shock compressed a huge quantity of gas. — **R. B.**



SUPERSTAR LBV 1806–20 outshines the Sun 40 million-fold and is 150 times larger. U.FLORIDA/MEGHAN KENNEDY

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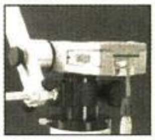

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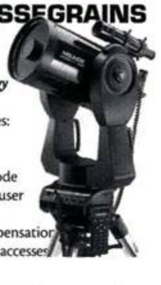

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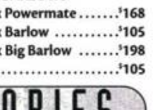

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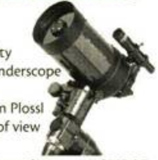

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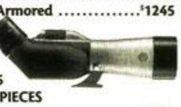

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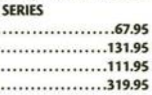

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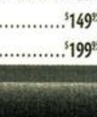

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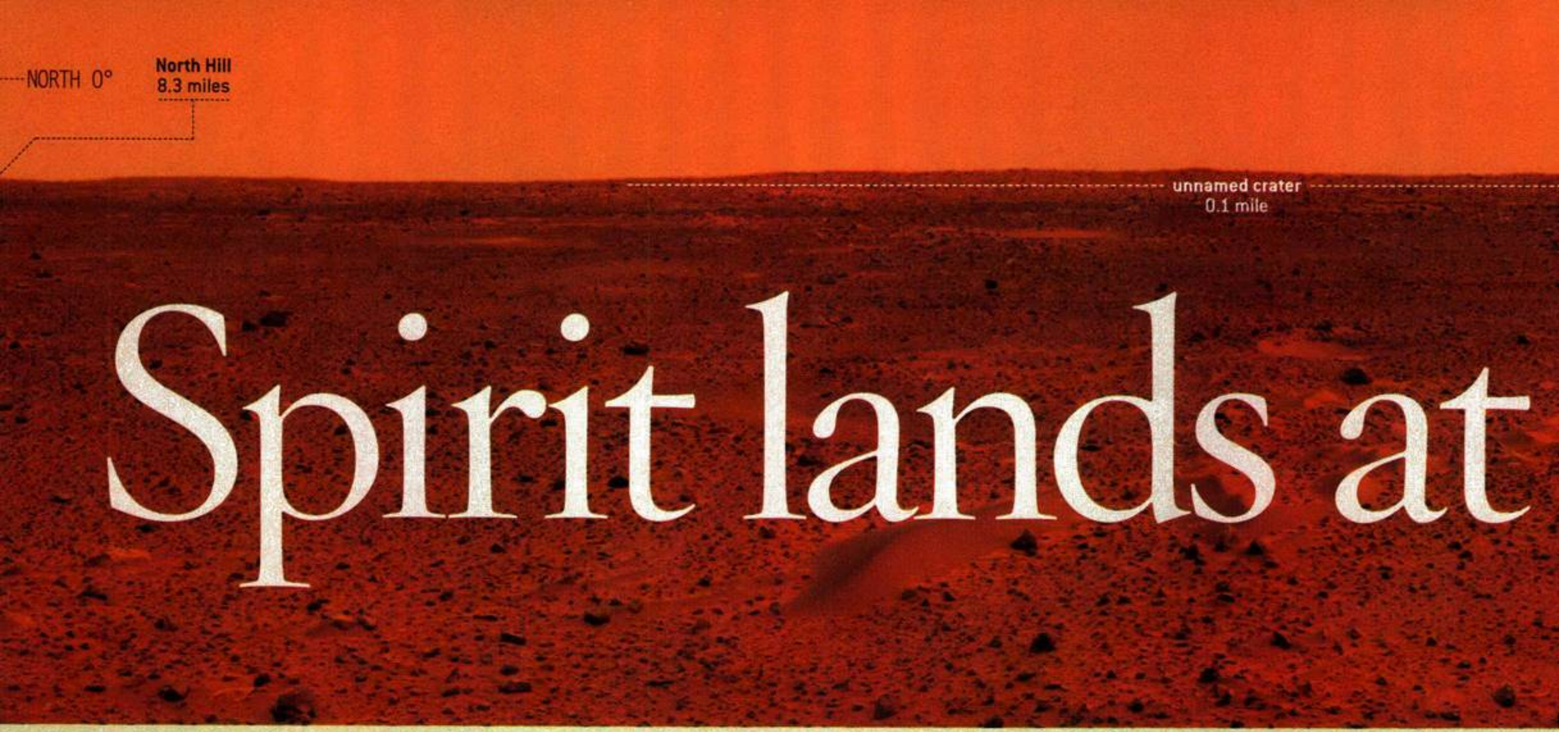


Spirit lands at

Spirit, the first of NASA's rolling robot geologists, landed smoothly in Gusev Crater. It took photos and soil data before software problems delayed its investigations. /// BY BRUCE MOOMAW

8:30 P.M. Pacific Standard Time, January 3, 2004: "We see it!" That blurt from a Jet Propulsion Laboratory flight engineer, listening for the signal that the Mars Exploration Rover (MER) Spirit survived landing, set off giddy celebrations in the control room. The delight was understandable because engineers and space officials were very nervous over Spirit's chances.

The MER project was developed at a frenzied pace, and NASA and JPL officials worried that if Spirit failed, it would be another blow for NASA, already battered by the Columbia shuttle tragedy, and for JPL, still recovering from the double failure of its 1998 Mars probes.

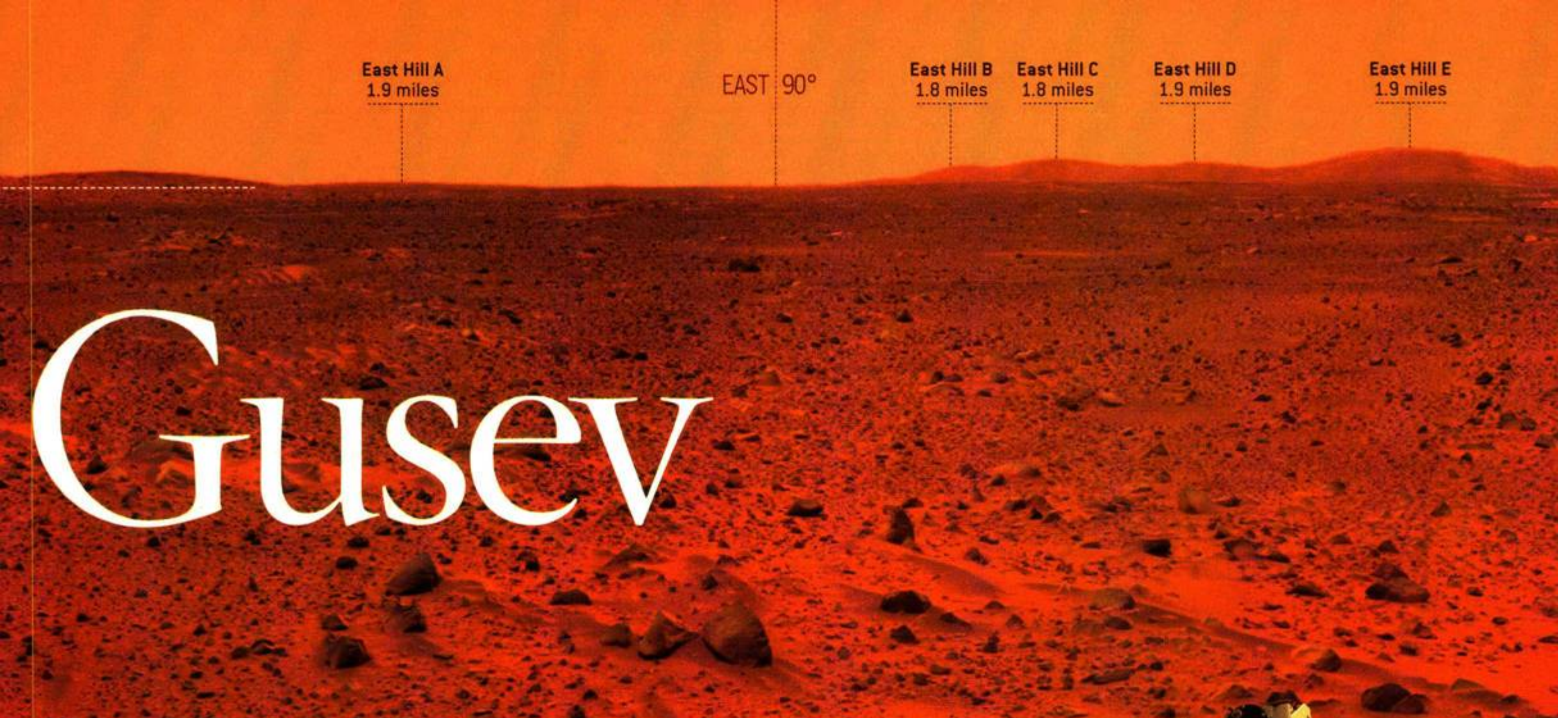
Spirit (and its identical twin, Opportunity) are crucial to America's Mars exploration program. This centers on the search for either present-day bacterial life or fossil evidence of such life during Mars's most hospitable days, more than 3.8 billion years ago.

The rovers carry no instruments to detect fossils, however. Instead, their job is to settle whether Mars has ever had large amounts of liquid water on its surface.

The evidence is maddeningly ambiguous. Mars's ancient highlands are sprinkled with valley networks that look like dried-up riverbeds. Some lead to impact craters whose floors show sedimentary layering, as though lakes once filled the craters. But the valley networks are far sparser than rivers on Earth, and they show peculiarities that suggest trickles of groundwater may have eroded them, rather than surface flows.

Yet mapping Mars from orbit has shown almost no mineralogical sign that volcanic rocks dominating the martian surface were exposed to water. This might be explained if the water were close to freezing. Possible traces exist of aqueous weathering of basalt in the northern lowlands, yet these rocks might be andesite, a rock that would not betoken surface water. Worse, instruments on the Mars Global Surveyor and Mars Odyssey orbiters have discovered scattered outcrops of olivine, a mineral quickly broken down by water.

No one knows what to make of all this. It may be that in Mars's Noachian Era — roughly its first billion years — the planet was frozen solid almost all the time. Perhaps planetwide cloudbursts carved the valley networks following giant impacts of asteroid-size bodies. Surface ice layers



Gusev

ON THE GROUND IN GUSEV, Spirit shot a spectacular 360° panorama (which continues across the next four pages). Spirit's first goal will be the crater rim lying 0.1 mile to the northeast. From there, Spirit will turn right and head for the East Hills. NASA/JPL/CORNELL

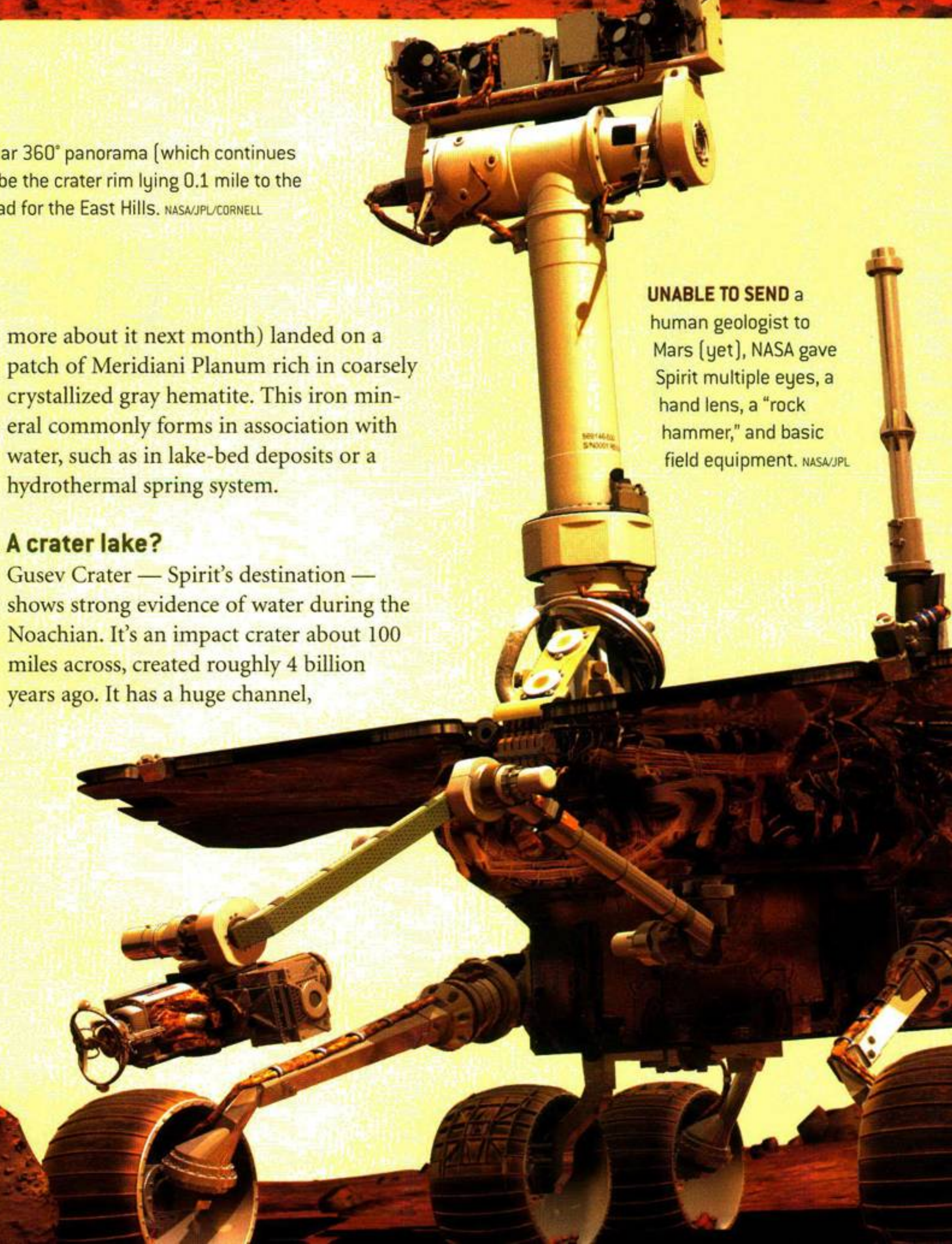
would have flashed into steam before falling as rain. Brief torrents could erode valley networks without much chemical weathering, while leaving Mars a hostile place for life. Or perhaps water flowed, but it was covered by a thick ice layer and the water was too cold for much chemical weathering to occur. This would have made a nastier environment for life than the oceans of early Earth, but not an impossible one.

To determine if Mars once had lots of water, the landers must go to likely "wet spots." If the landers discover little or no trace of water where it is most likely, then the odds of life ever existing on Mars drop drastically. But if some regions did have large amounts of water, these will be the best places for later missions to look for microscopic fossils or other biomarkers. Such missions — whether to analyze rocks on-site or rocket a pound or two back to Earth for analysis — will be very expensive. The richest landing areas will maximize the odds of success.

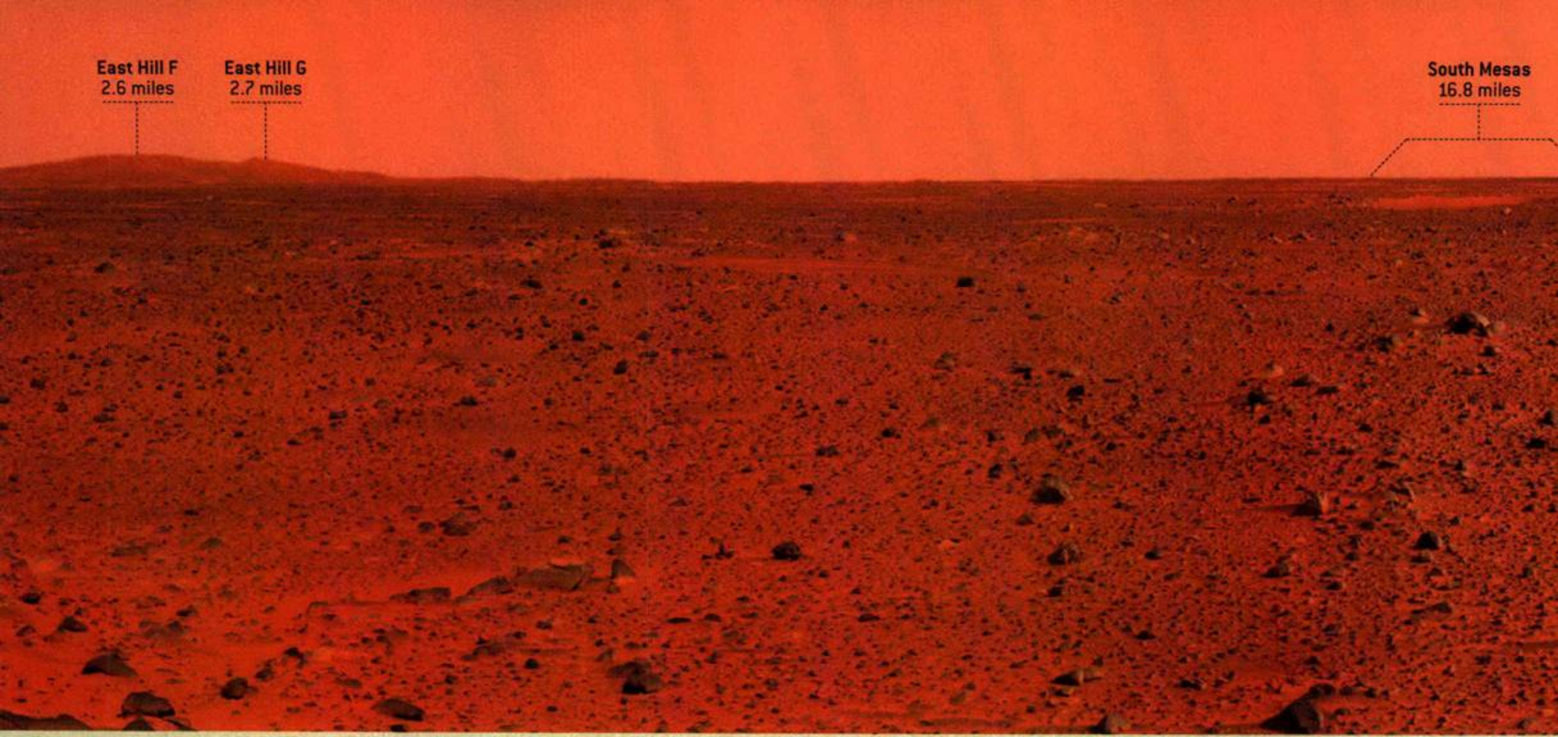
Hence the MER mission's two rovers. Opportunity (read more about it next month) landed on a patch of Meridiani Planum rich in coarsely crystallized gray hematite. This iron mineral commonly forms in association with water, such as in lake-bed deposits or a hydrothermal spring system.

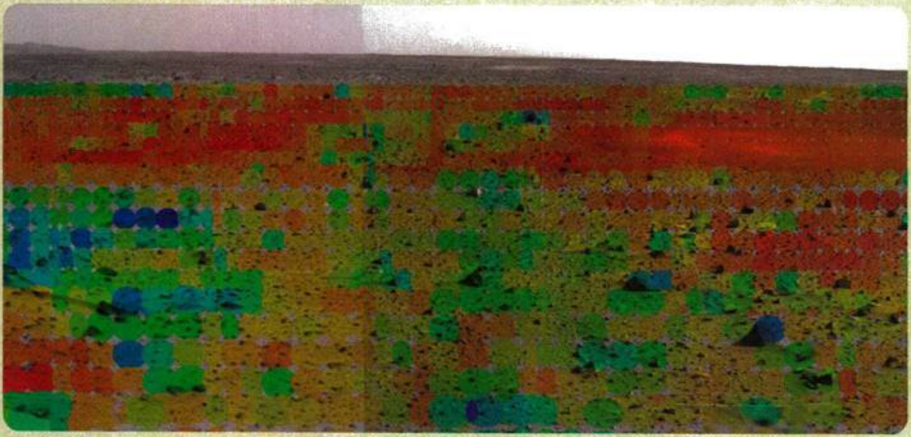
A crater lake?

Gusev Crater — Spirit's destination — shows strong evidence of water during the Noachian. It's an impact crater about 100 miles across, created roughly 4 billion years ago. It has a huge channel,



UNABLE TO SEND a human geologist to Mars (yet), NASA gave Spirit multiple eyes, a hand lens, a "rock hammer," and basic field equipment. NASA/JPL





SPIRIT'S MINI-TES SPECTROMETER mapped warmer areas in reddish colors and cooler ones in blues and greens. Sunlight heats patches of dust, while rocks tend to remain cooler. NASA/JPL/ARIZONA STATE/CORNELL

Ma'adim Vallis, running into it from the highlands to the south. Ma'adim is 560 miles long and 25 miles wide, and it likely saw flowing water for a fairly long time.

Ma'adim empties into southern Gusev at what looks like the remains of a river delta on the crater floor. Water may have flowed into the crater continuously or in repeated episodes — and it may have filled Gusev (perhaps with an ice cover) for long periods during the Noachian and even for several hundred million years after.

But Gusev is hard to interpret. It has two types of terrain: mesas at Ma'adim's mouth and patches of so-called "etched" terrain, which rise up to 300 yards above the crater's floor. The lower crater floor shows textures that have been deposited and eroded at different times. The amount of water flowing through Ma'adim seems to have fluctuated dramatically, but no one has any idea how long these periods lasted. Nor does anyone know if the erosion was due to new flows of water or to wind during dry spells.

Geological field gear

The instruments on Spirit are designed to unfold the crater's past. Its Pancams — two cameras mounted on the rover's mast — take multicolor stereo pictures. The same mast carries Mini-TES, a thermal emission spectrometer that looks for minerals linked to water (like carbonates and sulfates) by taking infrared spectra.

A mechanical arm on Spirit's front carries four more instruments: a Microscopic Imager to take high-resolution pictures of grains in rocks and soil; an Alpha Particle X-ray (APX) spectrometer to measure elements in samples; a Mössbauer spectrometer to identify iron minerals; and a Rock Abrasion Tool (RAT) to scour any weathered crust off rocks.

For all its equipment, Spirit faces an enormously complex task. Its controllers must tell it everything to do hours in advance, and at best, it can drive only 130 feet or so each day. It has an automated hazard-avoidance system, which uses pictures from two cameras mounted in front to build a 3-D map of the ground ahead. Once controllers choose an interesting target within 30 feet of the rover, it may take several days before Spirit can touch its instruments to the rock.

First looks at Gusev

When Spirit's first pictures arrived, they showed a landscape intriguingly different from that of the three earlier martian landers. The two Vikings and Pathfinder all chanced to touch down in some of the

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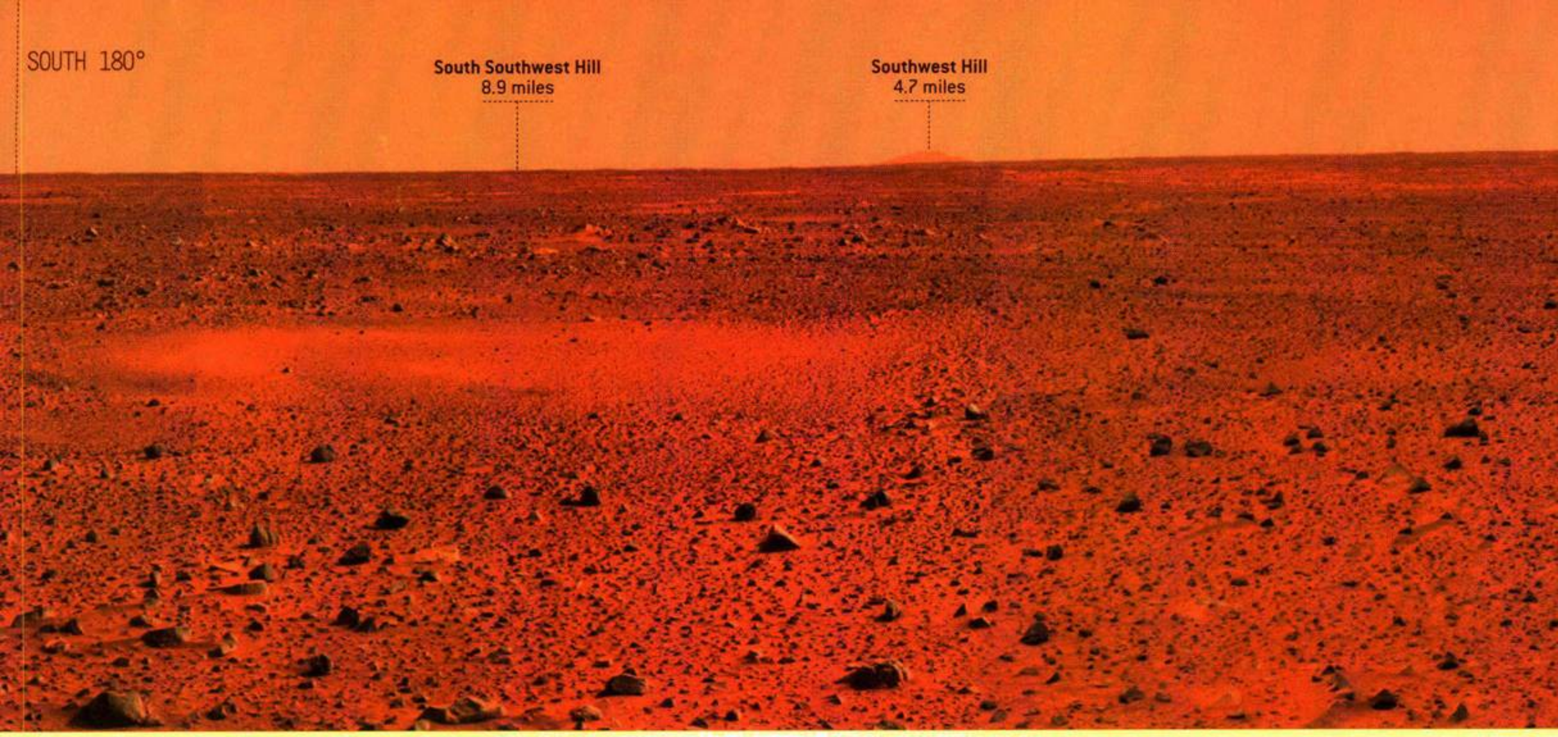
***Bruce Moomaw** has been intensely interested in space exploration since 1964. For the past five years, he has been a regular writer for the SpaceDaily news web site.*



rockiest places on Mars. The rocks at Gusev are numerous but small — thousands of them a few inches long litter the landscape, with very few bigger than a foot across. And the plain around Spirit is flat; only a few low hills break the eastern horizon. As MER chief scientist Steve Squyres of Cornell University confirmed, this is the best landscape for Spirit's scientific studies that anyone could conceive. It has multitudes of rocks big enough to analyze but almost none so big the rover has to swerve around them.

Another feature was immediately apparent in the surroundings. Many large, lighter-colored, roughly circular patches lie scattered across the landscape. Some are almost flat while others are shallow, rounded hollows. These appear to be patches of light-colored, fine dust.

Spirit landed in what Squyres calls the "scientific sweet spot." It's in one of two large dark streaks on Gusev's floor, where dust devils have swept away much of the dust. The surface around Spirit consists mostly of coarse sand and small pebbles.

Checking out hazards

Over the days following the landing, the rover sent back a stereo panorama of the landing site. Details sprang into focus.

Most of the dusty hollows — including the closest, dubbed Sleepy Hollow by groggy scientists on the first long night post-landing — are dust-lined craters. Given their size and shallowness, they're probably secondary craters gouged by boulders thrown from bigger primary craters. (Several such primaries lie nearby, each several hundred yards wide.)

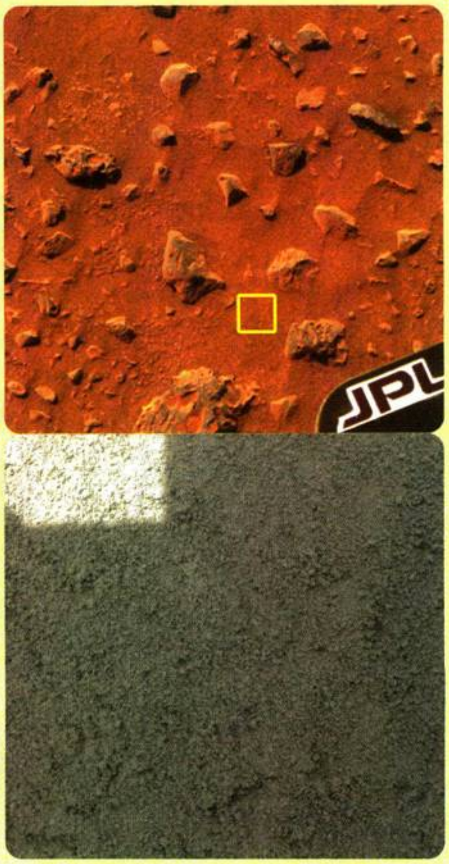
Engineers feared the fine dust filling the hollows might turn them into rover-traps, but the dust was less than an inch deep. Also, the airbag-wrapped lander rolled through the middle of Sleepy Hollow without sinking in more than a fraction of an inch.

The landscape contains almost no obstacles to keep the rover from driving as far as controllers want it to go.

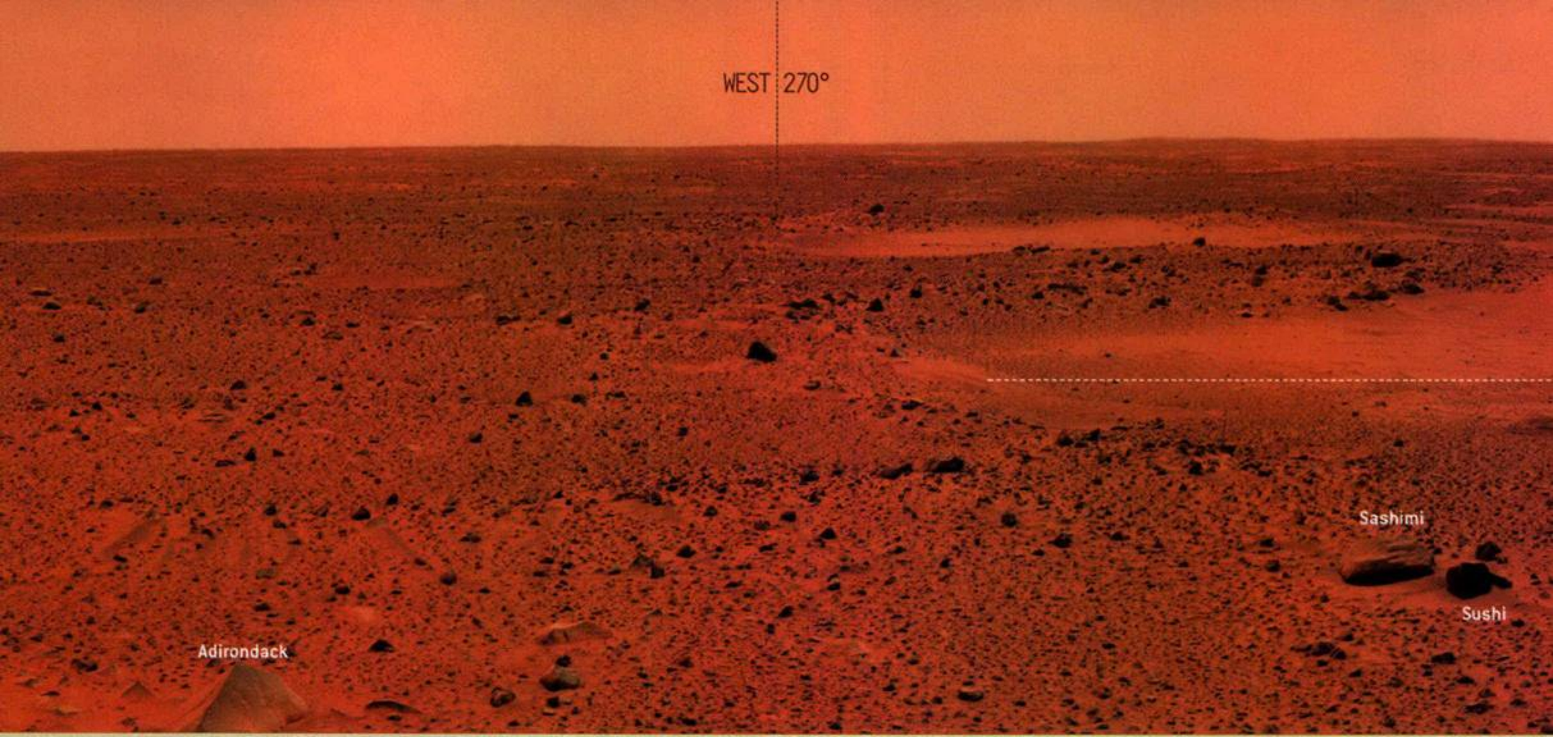
Ready to roll

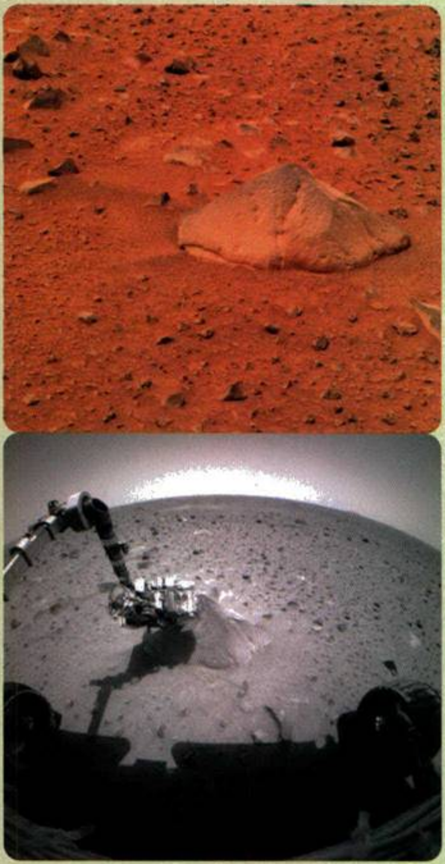
Before Spirit rolled off on January 15, it took multicolor pictures and infrared spectra of the landscape. The rocks are mostly dark and smooth; millions of years of gentle sandblasting have polished them. Some look so rounded they may have been rolled along by an ancient stream. Others appear sharper-edged than most rocks at the Viking and Pathfinder sites.

Their color suggests they are basalt — the dark volcanic rock that makes up most of the martian crust. Squyres says he does not "see anything in these pictures to suggest that we're looking at sedimentary rocks" — no visible layering, no visible grains or embedded pebbles. There is a less



TOUGH DIRT surprised mission scientists when they examined the soil in the square [top]. It contained iron, silicon, and other expected minerals, but it also had nickel and zinc, never before seen in Mars soil. The soil structure [bottom] also proved to be remarkably resistant to compression. NASA/JPL/CORNELL





ADIRONDACK ROCK [top] measures only about a foot from end to end, but it was the focus of Spirit's instrument arm soon after it rolled off the lander. While Spirit was at Adirondack, it developed problems that put the spacecraft into fault mode and sent mission engineers scrambling to find a solution. NASA/JPL/CORNELL

common family of rocks at the site that appears much lighter in color, but pictures suggest these may simply be basaltic rocks thickly coated with dust.

As for the basaltic boulders, flowing water may have rolled them across Gusev — or they may have been dug up from one of Gusev's ancient surfaces by a meteorite impact. The latter case would raise the possibility that Apollinaris Patera poured lava into Gusev. No sign of such flows is visible from orbit, but repeated impacts may have erased the evidence.

Scoping out the site

After Spirit mapped its surroundings with the Mini-TES spectrometer, chief investigator Philip Christensen of Arizona State University announced that the first results definitely show carbonates. If Noachian Mars had a dense carbon-dioxide atmosphere and lots of water, then much of the gas should have dissolved in the water and reacted with silicate rocks to form carbonates such as calcite or dolomite.

Repeated searches for martian carbonates before now, however, failed to find them. But in 2003, Christensen concluded that Global Surveyor spectra showed traces of magnesium carbonate, perhaps 2 percent, in soil all over the planet. He attributed this not to the soil containing pulverized carbonate rocks, but to tiny amounts of water vapor in the atmosphere. The water vapor reacted with fine dust particles to produce carbonates.

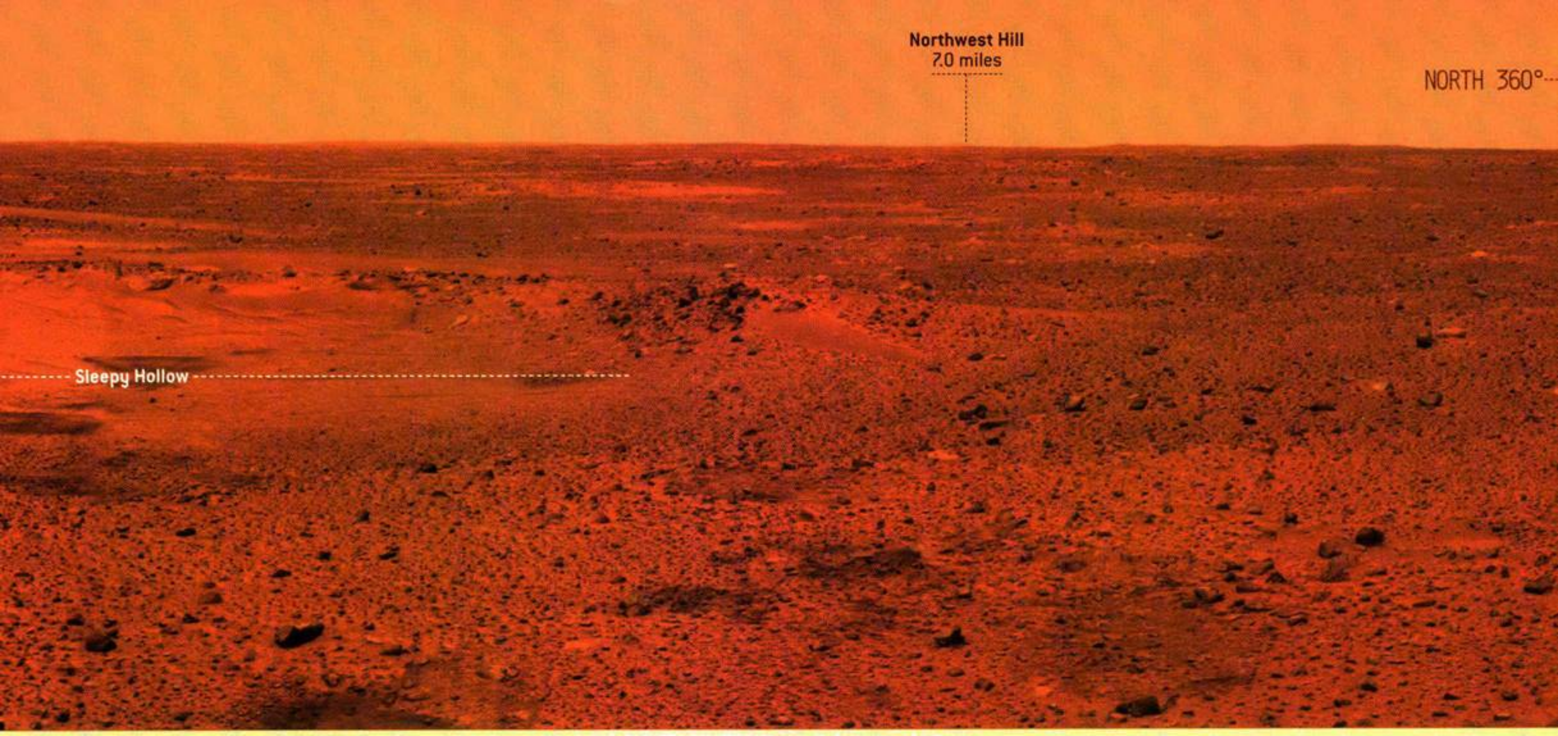
Spirit's spectrometer, however, showed clear spectral lines too weak for Global Surveyor to detect from orbit. These suggest that Gusev's surface has more carbonates than the surface average, perhaps 3 to 5 percent. The next step is to compare the spectrum of Gusev's coarse sand with the fine windblown dust. If carbonates turn out to be more concentrated in the sand (which is less easily moved by wind, and is therefore almost certainly made of Gusev's own native rocks), then we will have strong, direct evidence for lots of water in Gusev's past.

Moving off the lander

Spirit's first act on the surface was to lower its instrument arm onto the soil and analyze it. The APX and Mössbauer spectrometers found that the soil contains iron and silicon (as expected) plus chlorine and sulfur, also anticipated. New minerals identified include zinc and nickel.

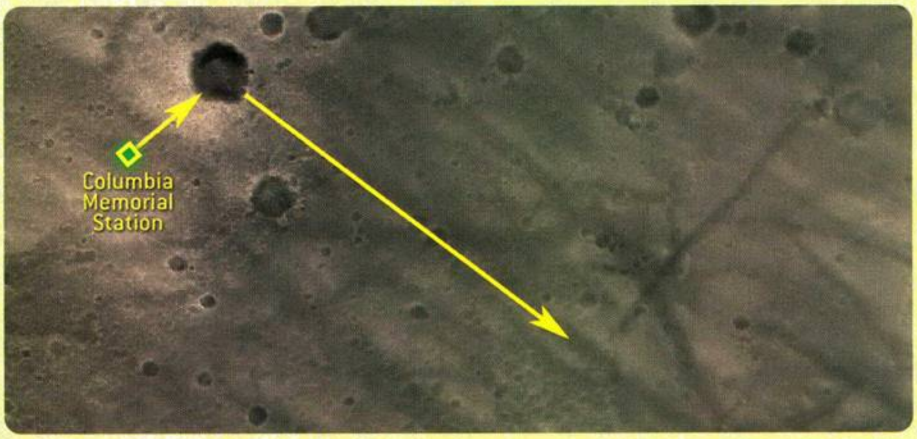
The soil appeared to the Microscopic Imager to be porous (see page 35), but it proved surprisingly resistant to compaction when pressed. After the soil survey, Spirit rolled over to a rock dubbed Adirondack by mission scientists (see left) and placed its instrument arm on it.

It was at this point that a "very serious anomaly" appeared, in the words of Pete



Theisinger, the MER project manager. Spirit was engaged in a calibration test when something went awry and the spacecraft put itself into fault mode. At press time, project engineers had concluded something scrambled the software that controls file management in the rover's flash memory. While they were uncertain of the problem's root cause, a failed mission appeared unlikely.

When Spirit returns to working order (probably with some limitations on its operation), the original mission plan calls for it to trench a few inches deep to reveal any soil-layering. Then Spirit will set off on a slow voyage of exploration.



SPIRIT'S MISSION PLAN sends it to a small crater northeast of the landing site, which has been dubbed the Columbia Memorial Station. A drive toward the East Hills may follow. NASA/JPL/MSSS

The rover will first drive about 800 feet northeast to the rim of an unnamed crater 650 feet across and about 60 to 80 feet deep. Its rocky, sloping rim, visible on the horizon, should be covered with rocks excavated by the impact. Spirit will pick through the ejecta because analyzing Gusev's older rocks is the mission's single, most important goal. This particular crater may not dig deep enough to open a window on the oldest layers of Gusev's past, but no bigger and deeper crater lies anywhere within driving range.

Scientists may also pilot the rover to look inside the crater. Several nearby craters imaged from orbit show clear signs of internal layers just a few yards thick. Odyssey's maps show two equatorial regions with high concentrations of groundwater, which may take the form of water ice buried a few yards beneath the surface. Gusev lies in one of these regions.

Head for the hills

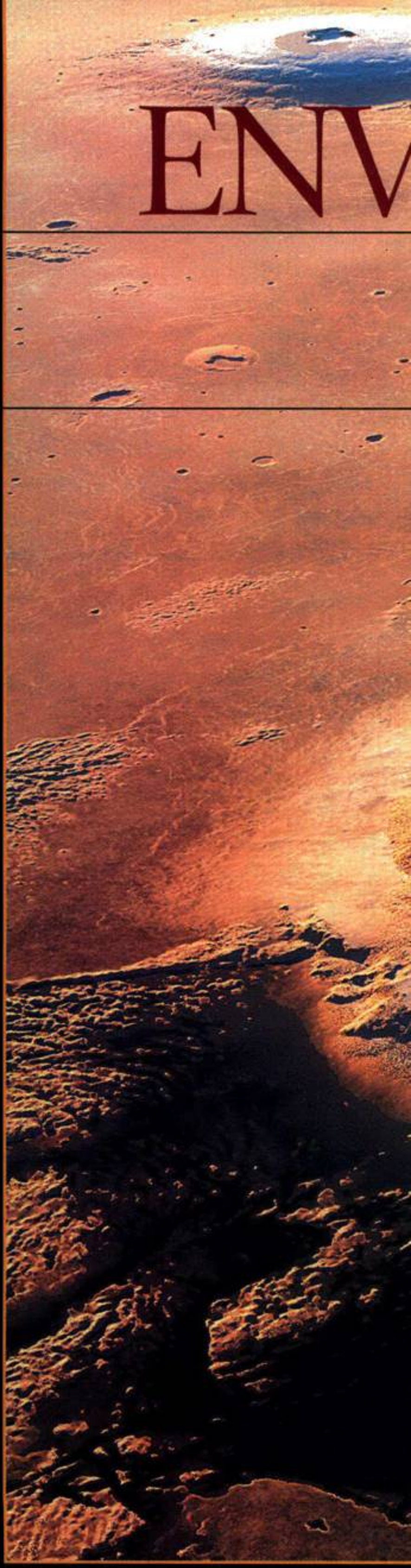
After poking around the crater, Spirit will turn southeast. Five mesas about 300 feet high and 2 to 3 miles away are clearly visible on the horizon. Scientists have dubbed them the East Hills. They are the only bits of etched terrain within the spacecraft's landing ellipse and represent an earlier era in Gusev's history.

There's no chance of Spirit reaching them by the end of its three-month primary mission, but the rover may work longer. Eventually Spirit will be crippled by the accumulation of dust on its solar panels and by the onset of martian autumn, shortening the days during which the craft recharges its batteries. Yet if Spirit survives for six months, it could reach the hills. There's no better overall goal for the rover after the crater studies. The closer it can get to the mesas, the better its instruments can examine them.

And who knows what else Spirit will discover en route? "I don't know what we're going to do" when the rover reaches its destinations, says Squyres.

"We will get there and we will see what we will see . . . ."

Let the good times roll. ■



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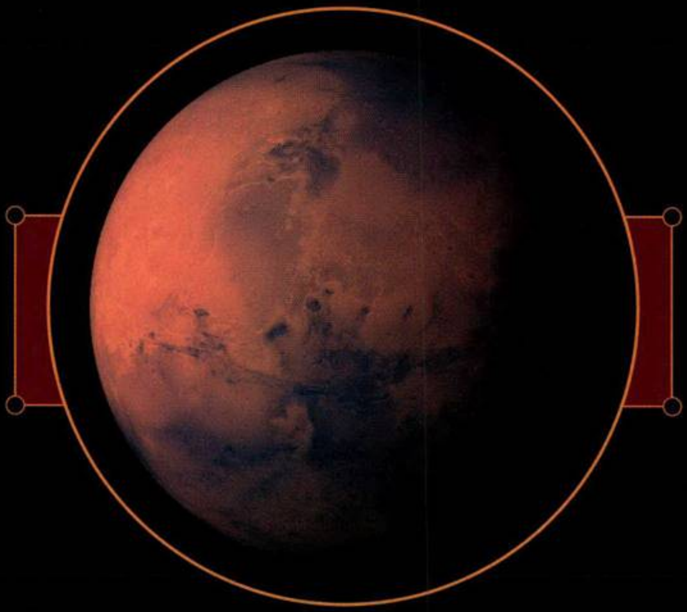


An artist's eye, a desktop computer, and lots of elevation data are all Kees Veenenbos needs to recreate scenes of today's Mars — or those of billions of years ago. /// BY ROBERT BURNHAM

HAVE YOU EVER DREAMED OF STANDING on Mars and watching sunrise from the top of Olympus Mons? Or maybe strolling the shore of Oceanus Borealis, a hypothetical ocean in Mars's northern lowlands?

Kees Veenenbos has done more than just dream about Mars. A web site developer for the city of Apeldoorn in his native Netherlands, Veenenbos creates computer images of scenes that put the yearnings of many an armchair astronaut into powerful visual form.

"Mars has always attracted us as human beings," he says. "Natural curiosity drove me, and I wanted to go there in my imagination."

Using a Windows-based computer with 512 megs of RAM, Veenenbos employs an application called *Terragen*. It turns elevations into landscape scenes, and the results are photo-realistic.

"I don't look on my renderings as art," he says. "The software lets me combine both realistic and speculative elements. But when the scene is dramatic, it certainly affects people as art does."

The elevation data comes from the laser altimeter aboard Mars Global Surveyor, which measured 640 million points on the martian surface. When mapping ended, the points covered Mars thickly enough to make shaded relief maps. But these fall short of the view you'd get looking out a spacecraft window.

This is where Kees Veenenbos steps in. He imports the elevation data into the *Terragen* software via a program called *3DEM* and displays it like a scene you'd see if you were approaching a landing site. To add realism, he colors the landscape.

"I choose the color of the surface to match what was seen from Mars Global Surveyor and from the Pathfinder lander."

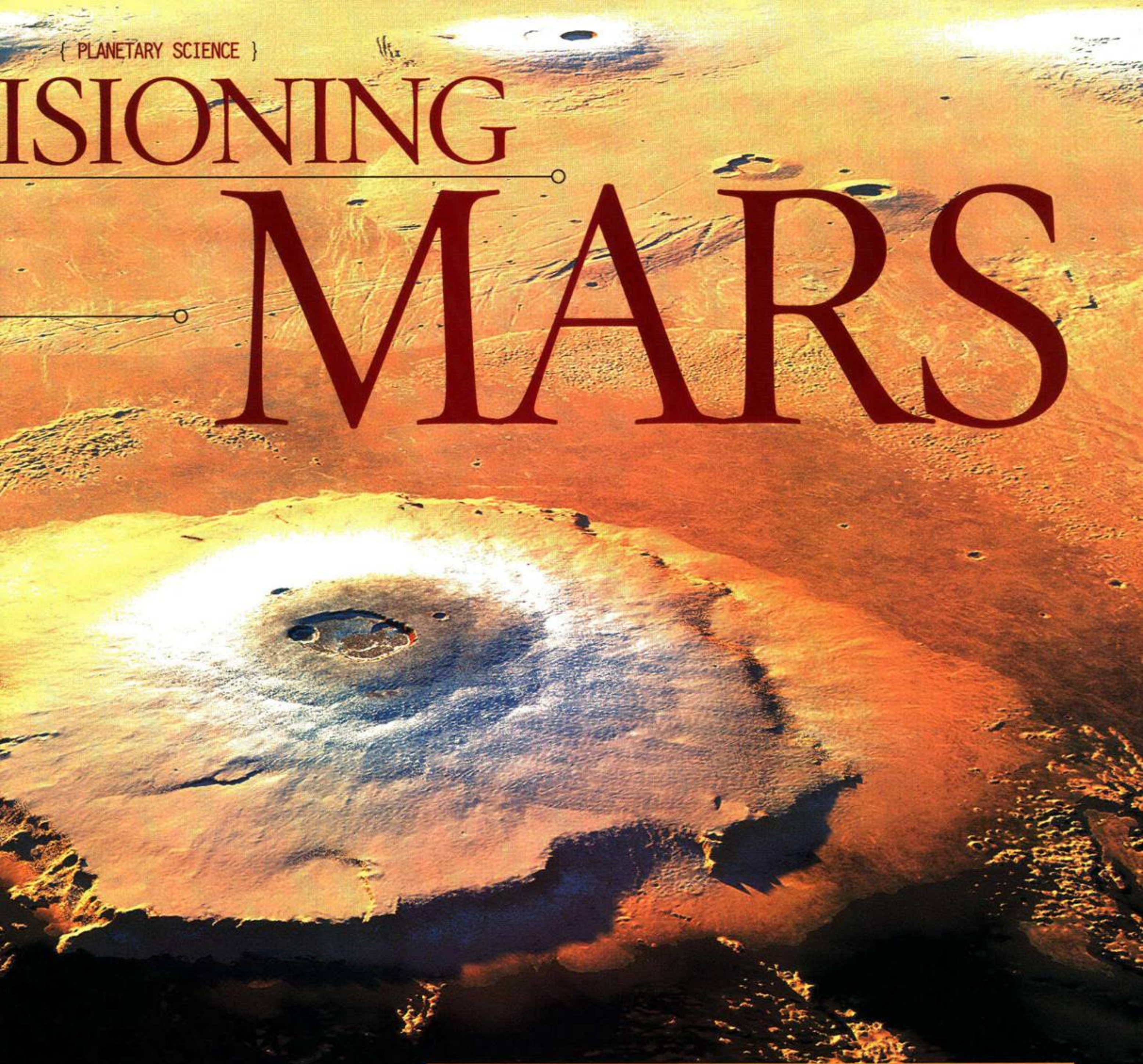
Besides today's Mars, Veenenbos often has turned his geo-camera on the martian past. Recent research suggests ancient Mars saw global ice ages, which could explain certain widely seen landforms. Extensive lakes or even oceans may have been possible also. Scientists are debating whether or not these features existed. But if they did, Veenenbos's renderings show what the Mars of three and four billion years ago may have looked like.

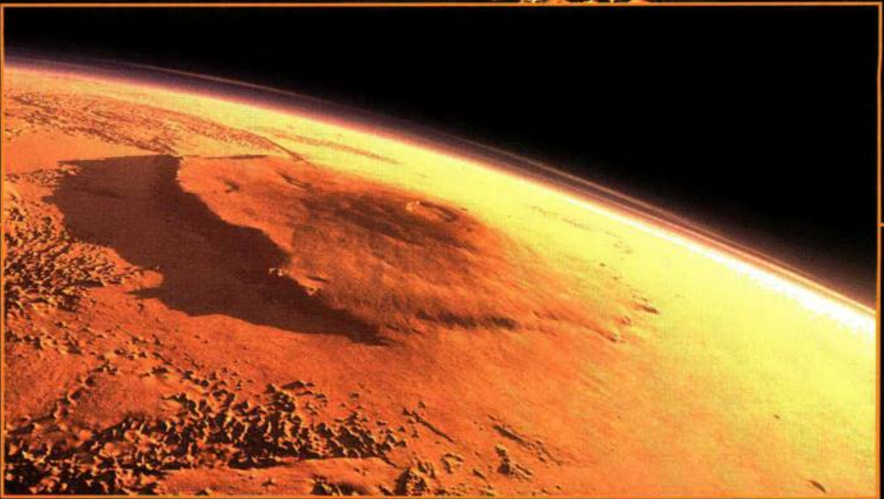
Few of us are ever likely to stand atop Ascraeus Mons and let our eyes walk to the horizon. But these images will take you as close as you can get — for now.

COLD, THIN WINDS, (above) planet-wide dust, and relentless aridity characterize Mars today.

{ PLANETARY SCIENCE }

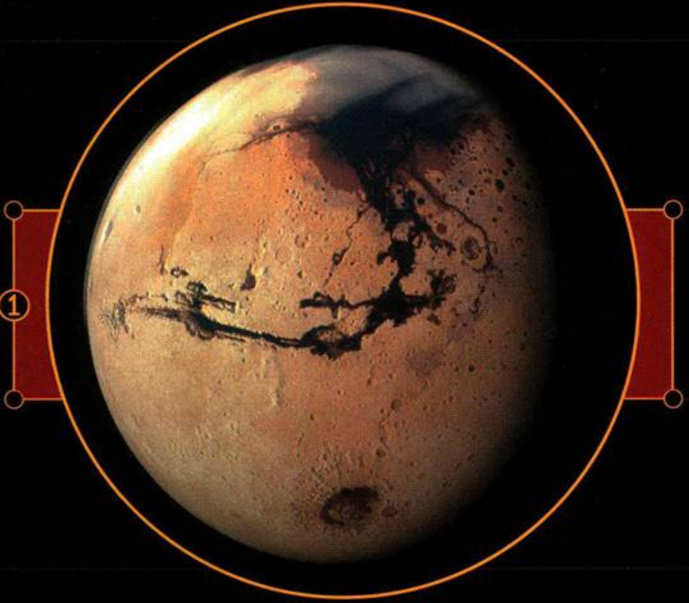
ISIONING MARS





LIGHT SNOW DRAPES OLYMPUS MONS (above) while dark water laps at its base in a scene showing Mars perhaps 4 billion years ago. ALL ILLUSTRATIONS BY KEES VEENENBOS

SUNRISE OVER OLYMPUS MONS (right) casts a shadow for dozens of miles. This view looks northeast.



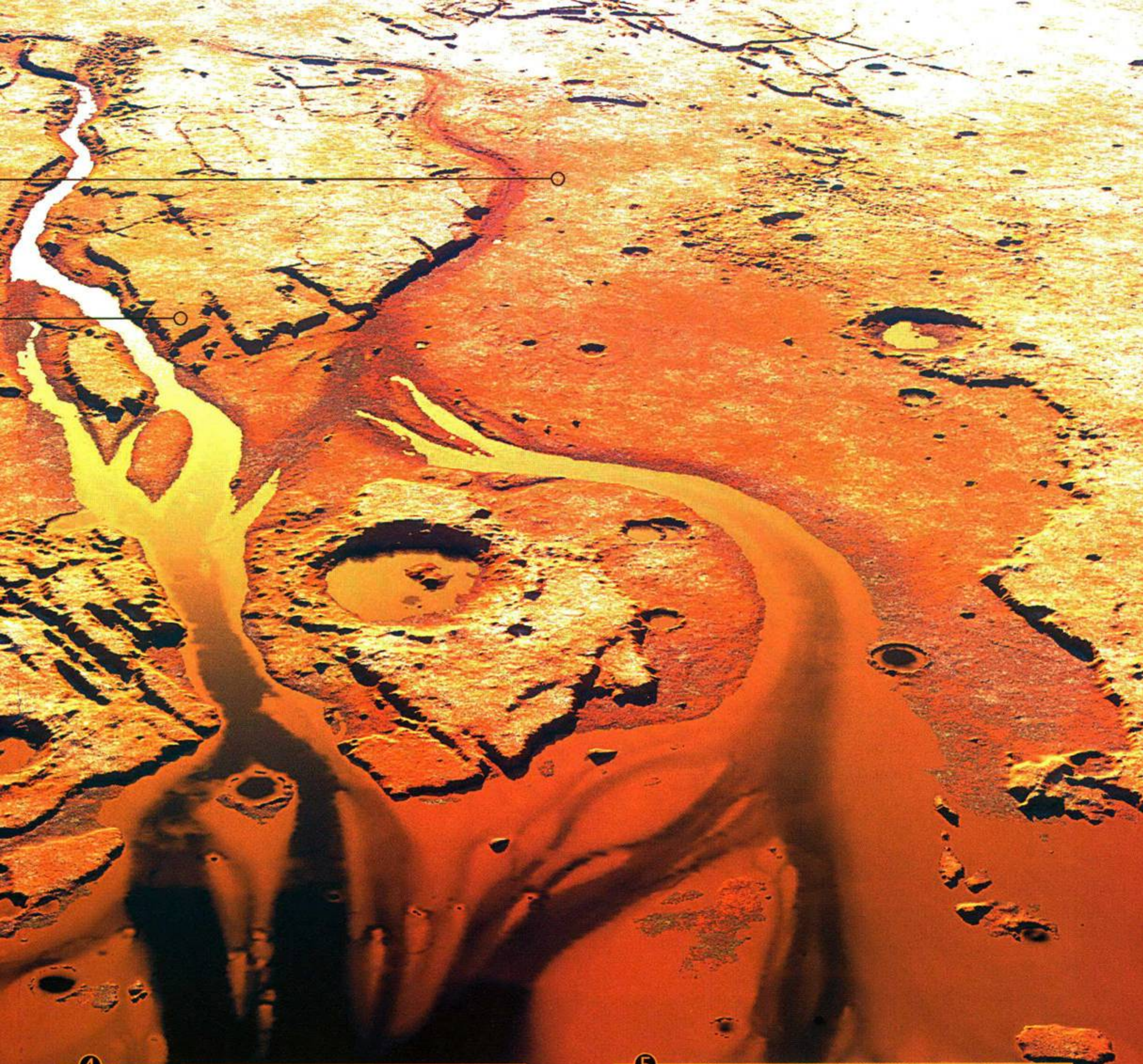
① **THE HEAT OF THARSIS'S VOLCANOES** may have liberated huge outflows of groundwater. Scientists debate details, but Valles Marineris and the channels east of it appear to have sent vast floods toward the north.

② **WHEN WATER FLOWED IN KASEI,** it eroded a landscape already heavily cratered by more than a billion years of impacts.

③ **FLOODS POURED DOWN KASEI VALLIS,** carving braided channels as the water raced into the northern lowlands. Today's dry channel-beds bear unmistakable traces of these ancient floods.

④ **A BIG IMPACT SCAR,** Isidis Planitia (left background) lies on the edge of the northern lowlands. The intended landing site of the ill-fated Beagle 2 probe, Isidis was targeted because it likely contained water at one point early in Mars's history.

⑤ **CRATERS AND WATER** lend a boggy look to the edge of the southern highlands in Arabia Terra long ago. The largest crater in the distance (top left) is Cassini, which is 260 miles (420 km) in diameter.



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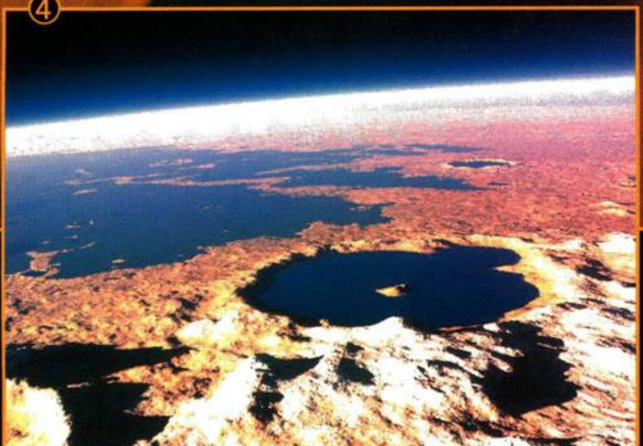

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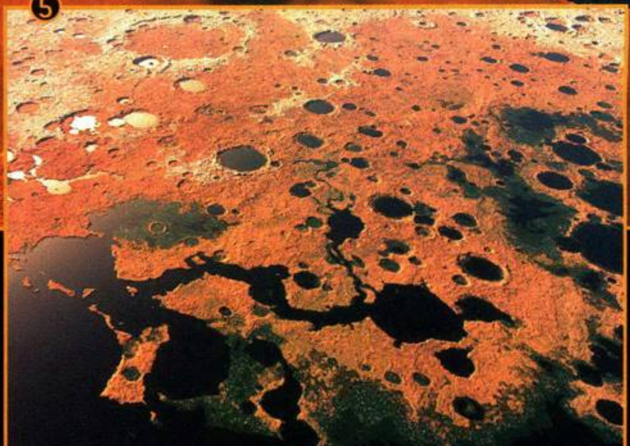

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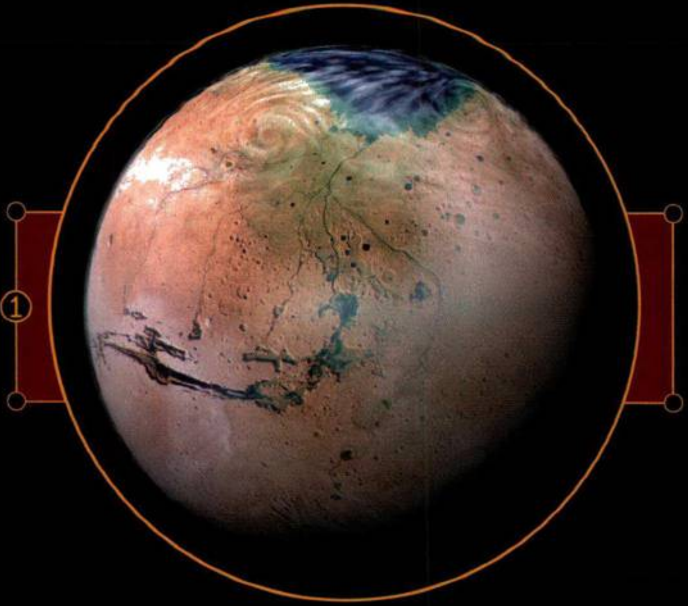

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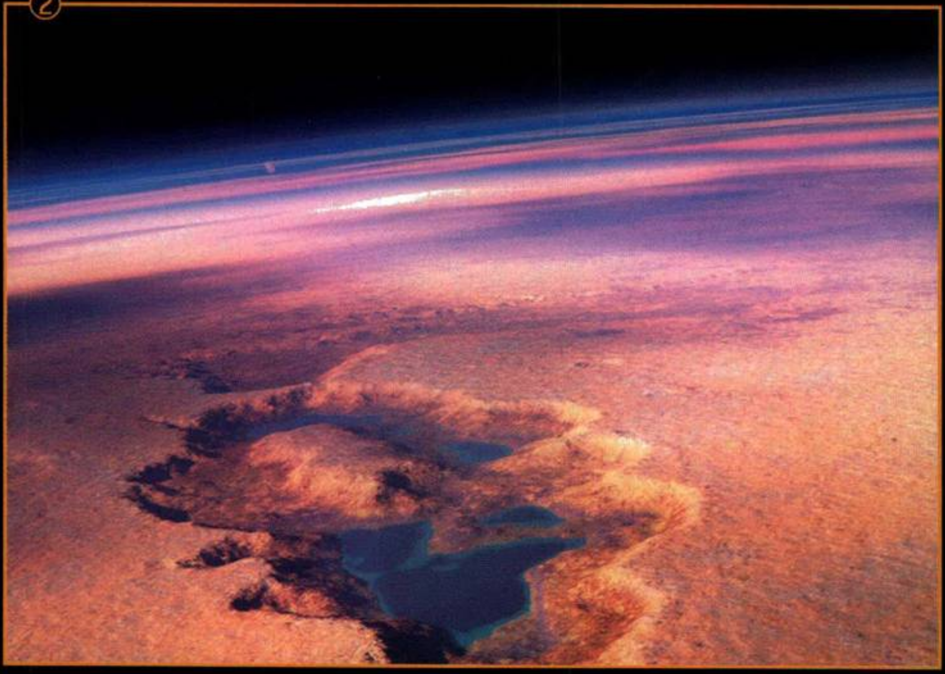

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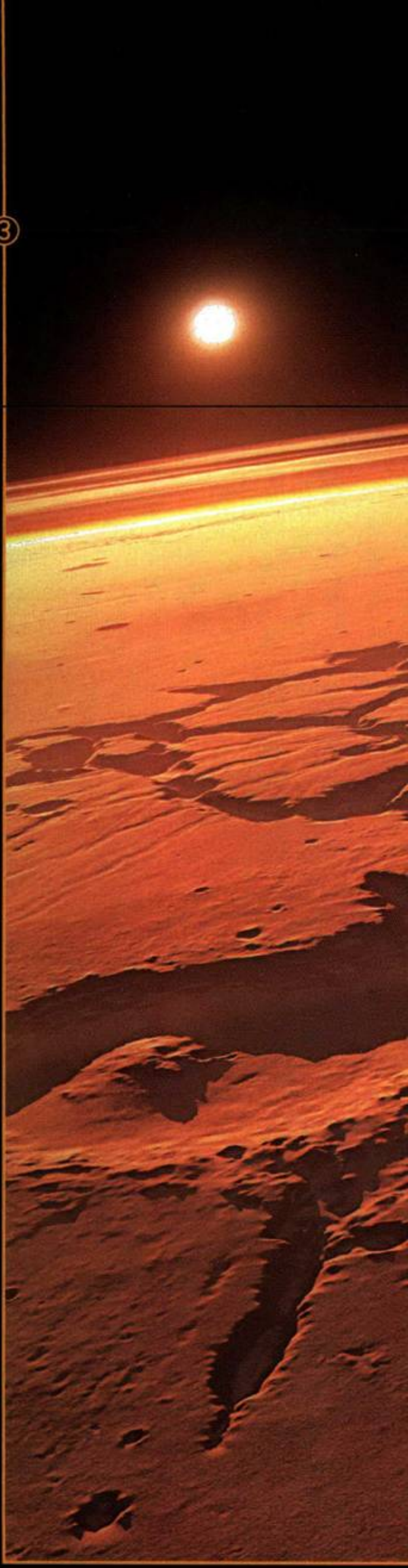


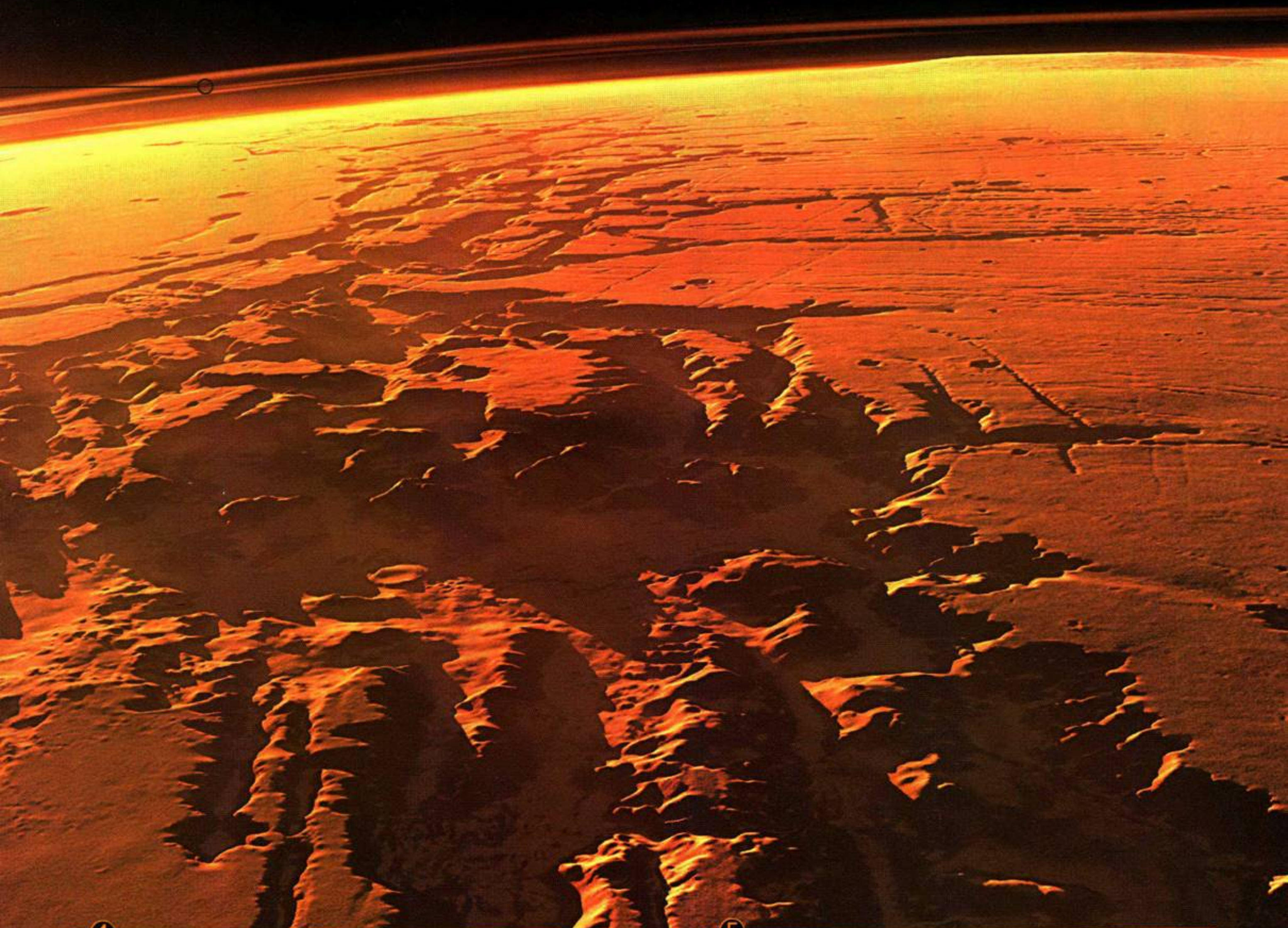
① **A "TERRAFORMED" MARS** might offer humanity a second home (or a third, after the Moon). Let a thousand years roll by and Mars could be turned at least partly earthlike.

② **HEBES CHASMA,** seen partly flooded in this view looking west, forms a nearly landlocked depression north of Valles Marineris. Thin clouds shadow the ground.

③ **ESCAPING GROUNDWATER** undermined the surface of Noctis Labyrinthus, which lies at the west end of Valles Marineris. The sapping operated most strongly along faults and cracks in the rock, producing the intersecting pattern the feature's name echoes.

④ **A LONG VIEW WESTWARD** over Valles Marineris shows the volcanic peaks of Tharsis breaking the horizon. Left to right, they are Arsia Mons, Pavonis Mons, Olympus Mons (in the distance), Ascraeus Mons, and Tharsis Tholus (at frame's edge).

⑤ **LOOKING EAST FROM ATOP ASCRAEUS MONS,** Tharsis Tholus makes a low bump on the plains, while Valles Marineris is barely visible toward the horizon at top left.



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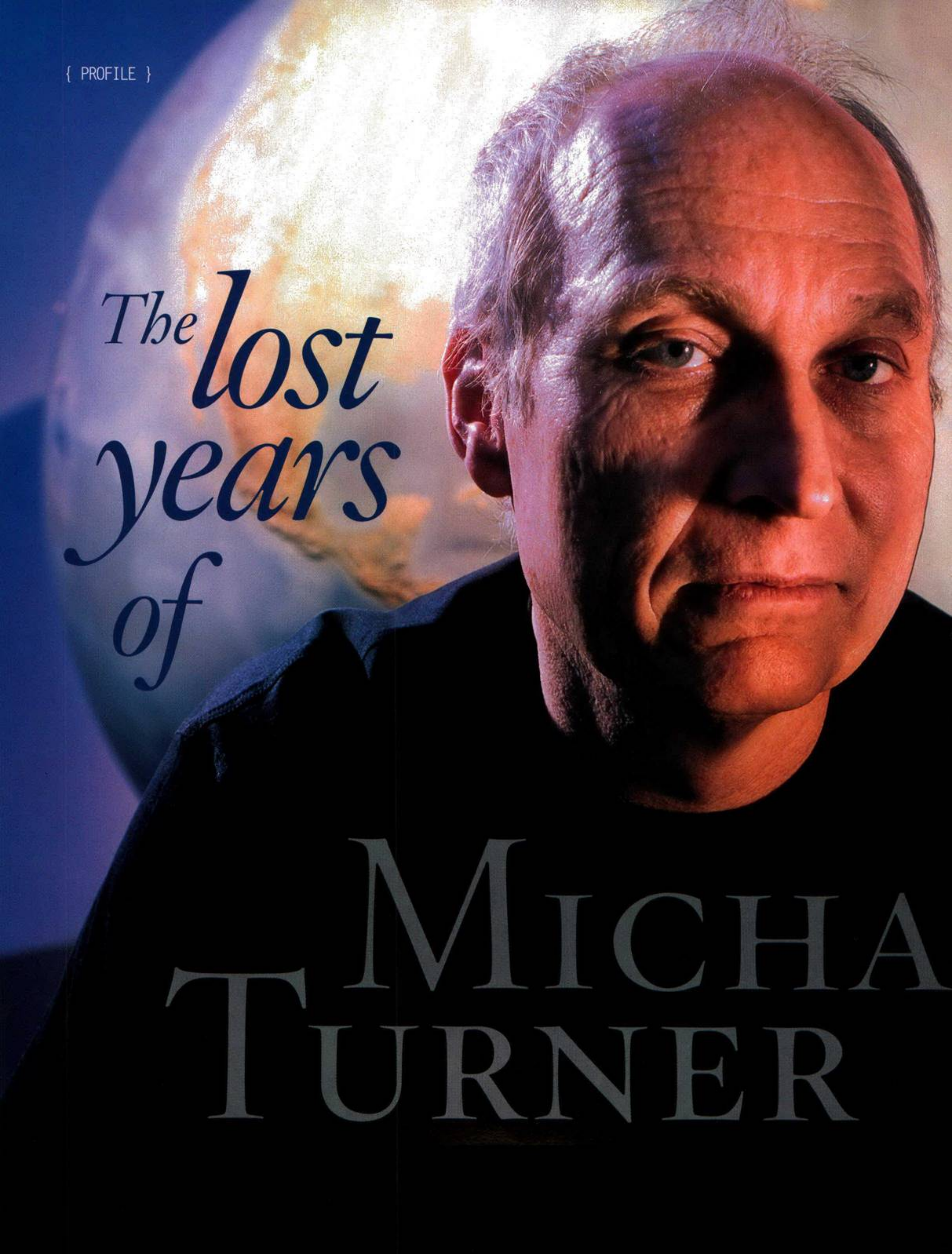


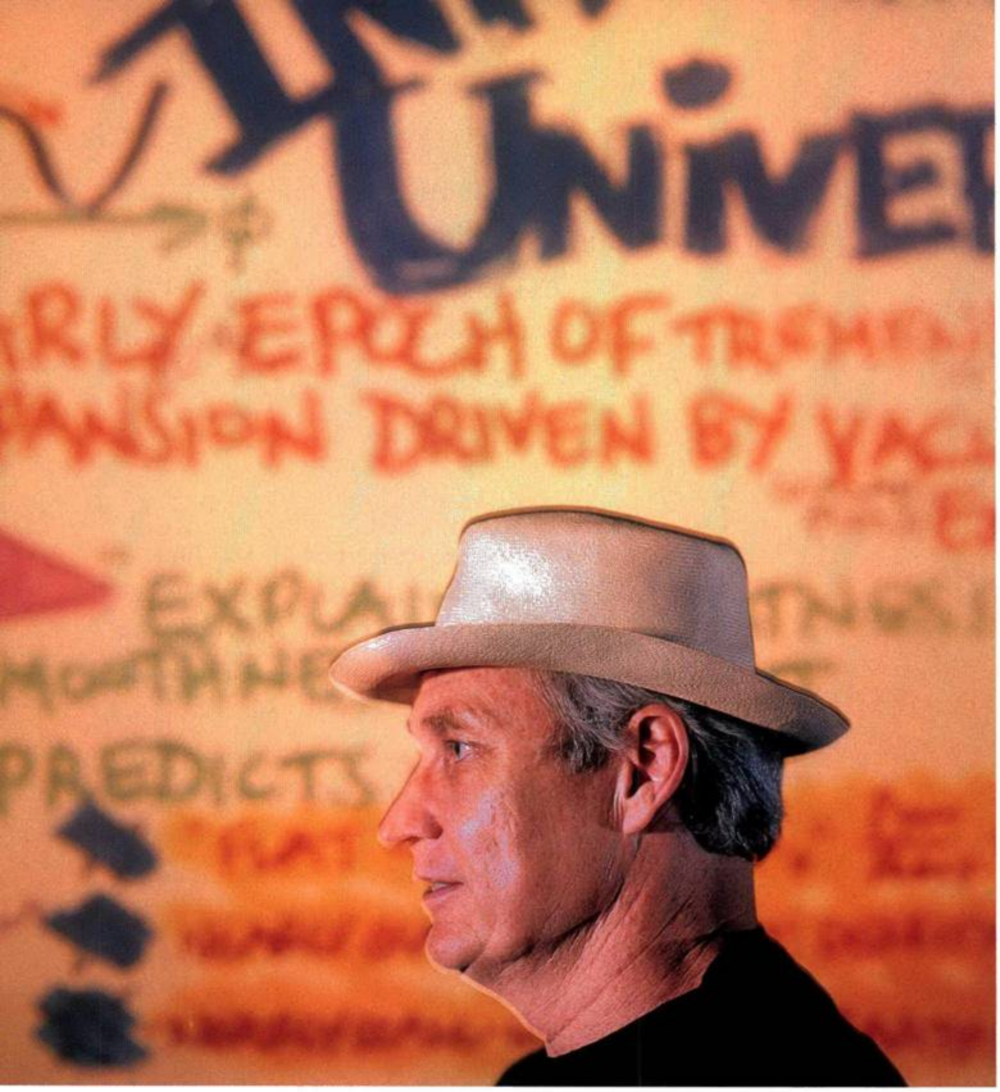
The lost years of MICHA TURNER

Find out how lab rats and Porsches started this world-renowned cosmologist on his quest to explain the origin and fate of the universe. /// TEXT BY STEVE NADIS /// PHOTOGRAPHS BY FRANCIS FORD

In 1973, the career prospects of Michael Turner looked inauspicious at best. The young physics graduate student had taken an unofficial leave of absence from Stanford University, ostensibly to find himself. Instead, he found himself living in a garage, scrounging to make ends meet by fixing cars, tending to laboratory animals, and serving as a paid volunteer for drug experiments at a local Veterans Affairs hospital. This was not the résumé most of his peers were compiling. Turner, now 54, admits he led a "fringy existence" during this period. "I rattled around like a billiard ball, not knowing what to do with myself."

Looking back on those "lost years" three decades later, Turner is convinced that all the missteps, wandering, and curious choices worked out for the best. Had he followed the straight and narrow path along with the rest of his Stanford classmates, it's unlikely he'd be where he is today: adeptly juggling his roles as head of the Mathematical and Physical Sciences directorate at the National Science Foundation, chair of the astronomy and astrophysics department at the University of Chicago, a staff scientist at Fermilab in Batavia, Illinois, and one of the world's best-known cosmologists. Over the years, Turner has played a leading role in shaping the discipline of particle astrophysics while advancing important ideas related to Big Bang nucleosynthesis, inflation, dark matter, and dark energy. "It's hard to find an area of cosmology Mike hasn't made key contributions in," says his long-term colleague, Edward (Rocky) Kolb, a physicist at the University of Chicago and Fermilab.

Looking at Turner today, it's hard to imagine what he was going through in his early 20s, when he searched for "relevance" and tried to figure out what to do with his life. "It was a time of great social upheaval, with the Vietnam War raging and society coming apart at the seams," Turner



explains. His roommates were medical students, and the contrast between Turner's and their chosen field prompted him to ask: "Should I be doing something more relevant? They had a purpose: They were going to save people. Meanwhile, here I was solving equations, and what did those equations mean?"

The life of a graduate student is always difficult. "You're preselected on the basis of taking notes and regurgitating, and suddenly the rules change. Now you're supposed to create something original, which can be a bit daunting." He got excited about particle physics as a CalTech undergraduate. He was partly inspired by Richard Feynman — one of the most influential physicists of the 20th century; Feynman won the Nobel Prize for Physics in 1965 — who tutored him one-on-one.

> **On weekends,** Turner looked after 1,000 animals confined to Stanford research labs. It was horrible work, which invariably left him covered in feces.

Feynman encouraged Turner to go to Stanford, where exciting experiments were underway at their famed linear accelerator. But when he arrived at Stanford in the early 1970s, particle physics was in a "lull," Turner says, "with nothing much going on." Physicists recently had learned that neutrons and protons were made up of quarks, but they had no idea how quarks were held together. The descriptions of quarks and other elementary particles were strictly qualitative, and no one knew how to get beyond that.

Distracted and disenchanted, Turner left school. He began searching for himself and got lost in the process. His housemates allowed him to sublet his room and move into the garage in exchange for lower rent. He also started a car-repair business on the side, which was convenient given his unusual living quarters. He had an elite client list, mainly Stanford physics professors, and an uncanny knack for auto mechanics. "Unlike many theorists," he explains, "I like working with my hands. Plus, Porsches are very cool."

When not working on cars, Turner earned up to $500 per study in drug experiments conducted at the Palo Alto V.A. Hospital. "I was one of their favorite subjects because I came in sober and was articulate," he recalls. One of the studies looked at the medical effects of THC, the

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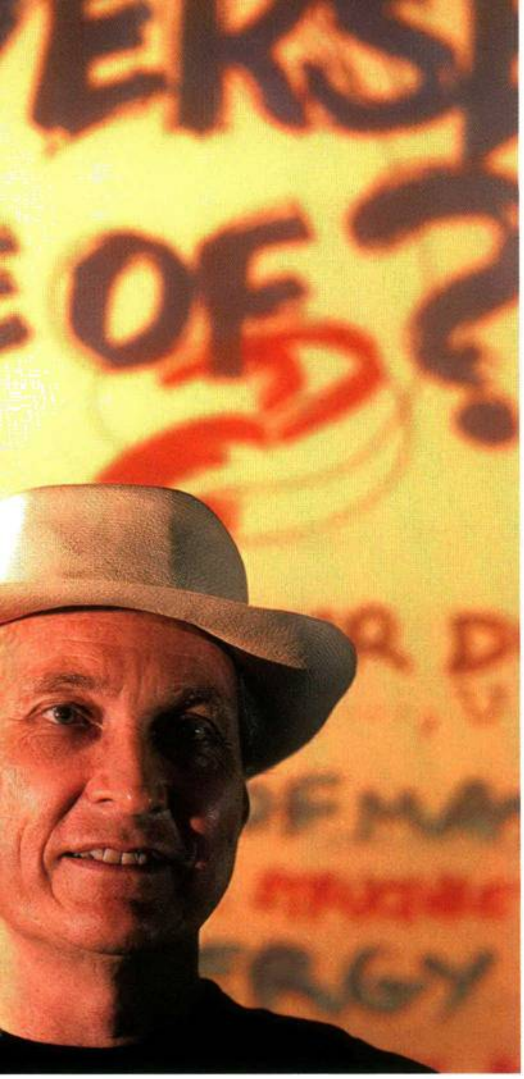
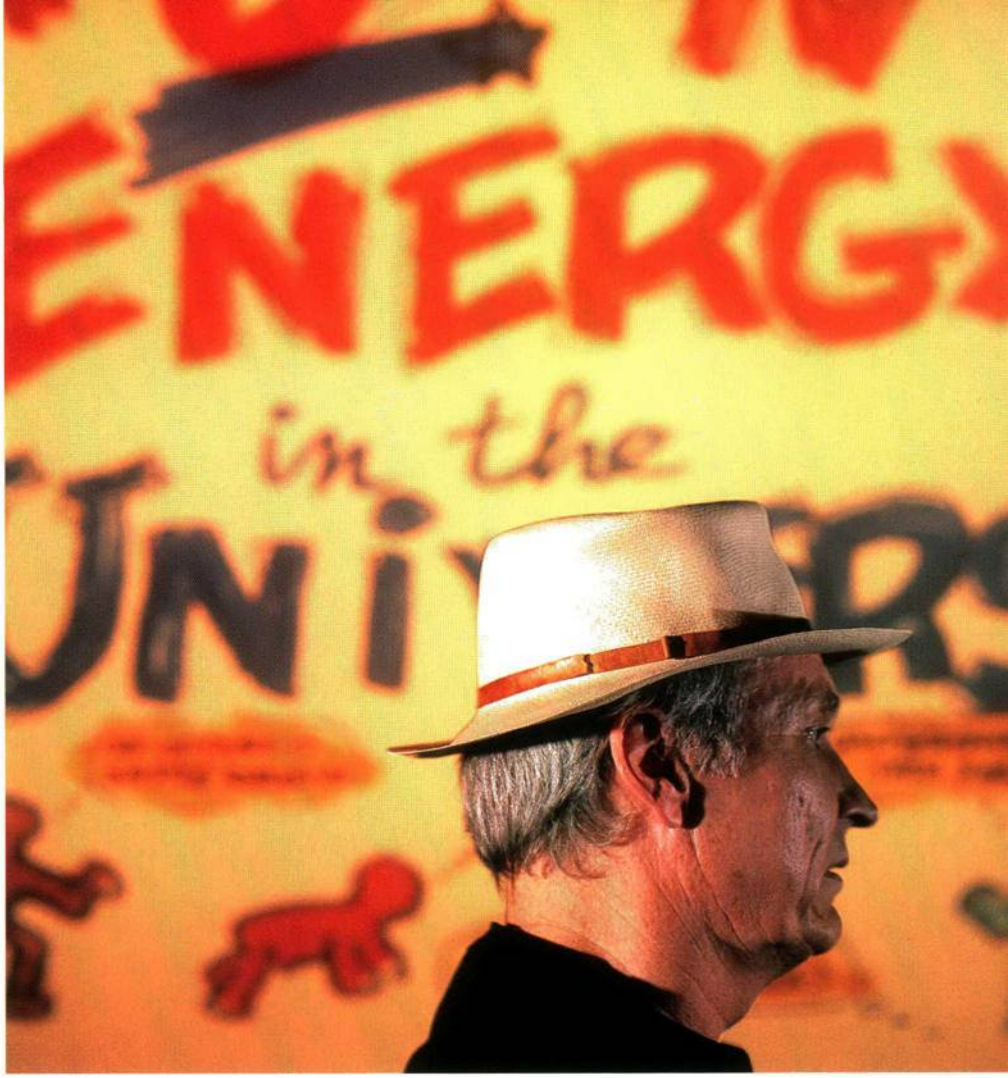
Steve Nadis *is a contributing editor and science writer who lives in Cambridge, Massachusetts.* Astronomy *would like to thank the Adler Planetarium and Astronomy Museum in Chicago for their generous hospitality during the photo shoot for this article.*





psychoactive component of marijuana; another involved valium. He never worried about ruining his mind for modest compensation: "When you're in your 20s, you don't think about things like that."

On weekends, Turner looked after 1,000 animals confined to Stanford's research labs. It was, he admits, "horrible work," which invariably left him covered with feces. "This was an awakening as to what the real world was like." Patching together odd jobs of this sort was not an easy existence, he concluded. Despite lingering confusion, he knew one thing for sure: This was not what he wanted to do with his life.

The road back to academia started with a course he audited at Stanford on gravitation and cosmology. He resolved to finish his Ph.D. but was uncertain about which direction to go. Physics professor Robert Wagoner had money to support research on gravity waves, so Turner worked for him and did a thesis on general relativity. It took him seven years including the two-year hiatus (in the latter stages, he called himself a "graduate student emeritus"), but Turner finished his dissertation in 1978.

At the time, he was bent on teaching, not yet knowing how much he liked research. He was particularly keen on a job at California State University, Fullerton, that never materialized. Then David Schramm, the University of Chicago astrophysicist who died in a plane crash in 1997, called and said: "Come to Chicago — you'll do great things." At the same time, Turner was being courted by William Press, then based at Harvard (currently the Deputy Laboratory Director for Science and Technology at the Los Alamos National Laboratory). Swayed by Schramm's enthusiasm, Turner picked Chicago.

Schramm became his mentor, cultivating his interest in the connections between particle physics and cosmology. "Why don't you think about it?" Schramm suggested. Turner, who had a fully funded two-year postdoctoral fellowship, dove right into Big Bang nucleosynthesis. He and Schramm tried to establish the number of quark "flavors" by determining the number of neutrino types, and then using that knowledge to calculate the universe's baryonic density.

Wagoner, who spent a year at Chicago on sabbatical, tried to discourage Turner from getting too deep into the cosmology quagmire. He told his former advisee to give up the early universe business and go back to gravity waves. In the 1970s, Kolb explains, cosmology wasn't seen as a legitimate science: "It was not the kind of thing *real* physicists did." But Turner had a hunch he was onto something big and shunned Wagoner's advice. "I followed my own nose," he says. "Sometimes you can smell what's in the air."

Turner considered himself fortunate to be at the University of Chicago, "a place where people were interested in cross-cutting ideas." Particle astrophysics flourished because of the interdisciplinary culture there. After finishing his postdoc, he was offered a faculty job. "While making their decision, they didn't ask: 'Is he an astronomer or a physicist?' — a question that would have come up at other places. Here, I could put the two together without having to worry about it."

That synthesis, merging "particle" with "astrophysics," turned out to be remarkably fruitful. Turner was guided along this path by the conviction that the combined approach held "the key to answering the most pressing questions in cosmology" — a sense that the composition and structure of the universe are ultimately dictated by processes occurring at the earliest times and on the tiniest scales. "Elementary particle physics is not just about breaking things down into smaller and smaller bits, it's part of a larger fabric related to the mystery of why we're here."

> The movement needed a guerrilla – one to provoke the status quo. Mike happily took on that role. – LAWRENCE KRAUSS

In 1983, Schramm and Fermilab director Leon Lederman decided to start an astrophysics group at the lab, which was a bold concept at the time. They lured Kolb from Los Alamos to join Turner in heading up the new group. "It was like giving two kids the keys to a hot new car," Kolb says. "We kept expecting Leon to take the keys back."

Turner and Kolb took particle astrophysics for a test drive at Fermilab. According to William Press, the University of Chicago became "the mother church to this order." Seventy-five percent of the people working in early-universe physics today, according to Kolb, are affiliated with either the University of Chicago or Fermilab.

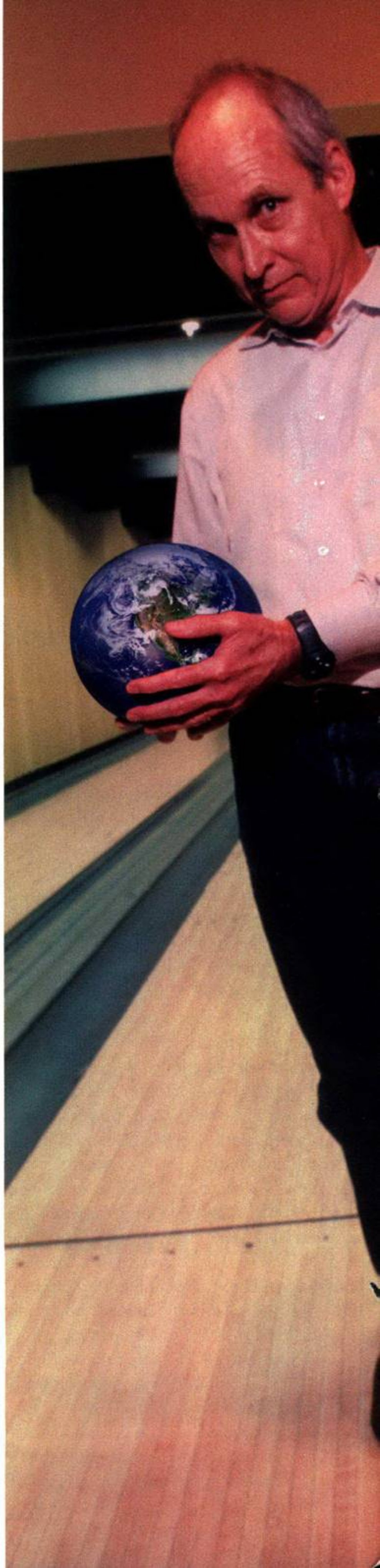
The field began as a "guerrilla movement," claims Lawrence Krauss, a physicist at Case Western Reserve University in Cleveland, Ohio. Back then, particle astrophysics was not respected by either particle physicists or astrophysicists. "The movement needed someone to play the role of a guerrilla — to push from outside the mainstream and provoke the status quo. Mike happily took on that role."

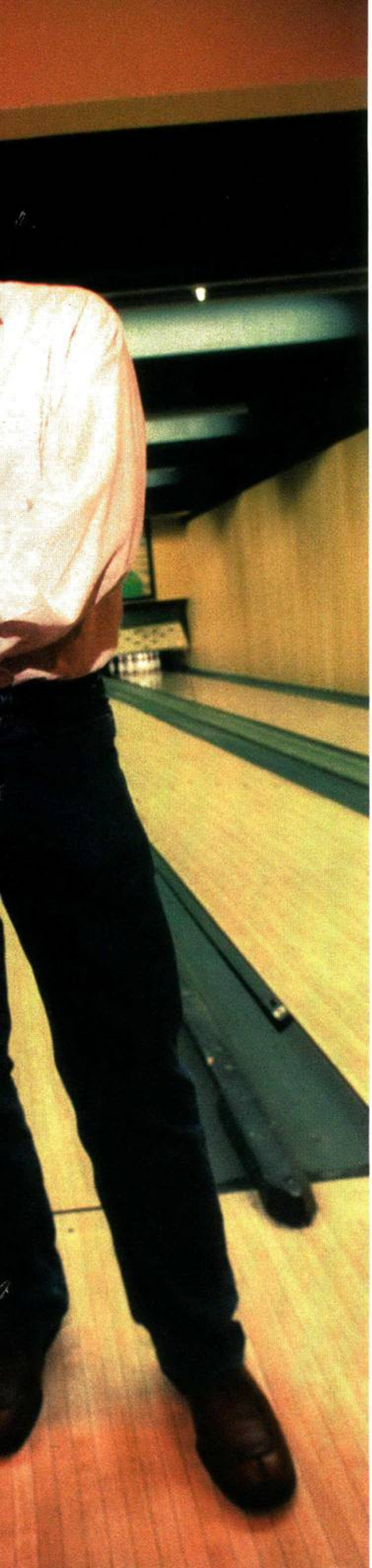
During this period of "freewheeling inquiry," says Turner, "we got the big ideas on the table — inflation, cold dark matter, the cosmic microwave background anisotropy, and the astronomers set out to prove us wrong." Eventually, he notes, "yesterday's revolution became today's orthodoxy." And an anachronistic institution called "primordial pizza" played a big part in that transformation.

Throughout much of the 1980s, researchers gathered on Monday nights in the basement of Turner's home to chomp on pizza and exchange wild notions. Turner refers to these meetings as "our improv time" when "there were no rules or pretense." The proceedings were guided by an "adventurous spirit, without any adults around to supervise," adds Kolb. "People weren't afraid to come up with outrageous ideas that might be wrong. But we were careful about what we published." Turner claims that more research papers came out of those Monday night sessions than any forum he knew of.

Primordial pizza was the right thing for that time — "the go-go, junk bond days of the 1980s," as Turner puts it — and those brainstorming sessions were wildly productive. But the times changed, and the data finally caught up with the ideas. The climate today is very different, he adds. "Everyone is paying close attention to observations, mainly because we *have* observations."

In 1984, Turner and Krauss proposed resurrecting the cosmological constant in a paper that was poorly received due in large part to a lack of empirical evidence and general scientific curiosity. In a 1995 paper, the two men again argued that the cosmological constant was needed to provide the mass necessary for a "flat" universe. This time, the reception was much better. Eighty years after Albert Einstein proposed the idea, Turner had anchored it in the realm of scientific fact.





Turner coined the phrase "dark energy" to describe the driving force behind the universe's accelerated expansion. According to Princeton University cosmologist P. James E. Peebles, Turner is "an adept coiner of phrases." He is also responsible for the terms "WIMPs" (weakly interacting massive particles) and "precision cosmology." Given his facility with words and flamboyant nature, Turner became an unofficial spokesperson for the field of cosmology. "He's willing to take the time to talk to people or to the media, and he's good at it," Kolb says. "He's a great promoter," adds Krauss, "with a knack for taking interesting areas, raising their profiles, and getting people interested."

Some of his most widely publicized "lobbying" occurred in 1998 during a debate with Peebles at the National Museum of Natural History in Washington, D.C. The topic under debate was: "Cosmology solved?" Turner argued the affirmative, answering, "Quite possibly!" For the first time, he maintained stoutly, cosmologists had a firm grasp on the universe's origin, evolution, and ultimate fate. Peebles disagreed, saying that in view of all the unknowns, the picture was anything but clear. The evidence accumulated since 1998 supports a more upbeat outlook, Peebles concedes. "I'm impressed with how well the pieces fit together now. It seems that Michael's optimism six years ago was warranted."

Obviously, Turner is pleased that particle astrophysics has yielded such a huge payoff. Initially, he was worried there wouldn't be a payoff. "Our approach really worked," he beams. "We were right to be excited." At the same time, he adds, skeptics like Wagoner and Peebles were right to be cautious because most things don't pan out. "This time we got lucky."

For his part, Turner has focused much of his attention over the years on observational strategies that may illuminate the so-called "dark side of the universe." He has developed theories on how dark matter may consist of elementary particles left over from the Big Bang and how these particles, in turn, affected the formation of structure in the universe. In particular, he has championed one hypothetical particle called the axion, and he ponders how to snare such an elusive quarry, if indeed it exists.

One of the things Turner likes most about his chosen field is its incredibly vast range, "extending from things smaller than you can imagine to things bigger than you can conceive." And he enjoys the fact that "you never know what you have to learn tomorrow."

He's especially excited about the challenges "tomorrow" holds: testing the inflationary model, and understanding the nature of the dark matter that holds the universe together and the dark energy that is pushing it apart. "We've explained the universe by saying 96 percent of its mass and energy are in some new, mysterious form, meaning these adventures aren't over. We're still in the middle," he says. "It also means this marriage between particle physics and cosmology will last a long time. It's not just Turner and Kolb going off on a weekend together."

Looking back, he is forever grateful to his old friend David Schramm for pointing him in the right direction. "Science is all about passion," says Turner, who inherited some of his mentor's enthusiasm — a fact borne out by the number of exclamation points appearing in his cosmology papers. "Most day-to-day work is boring; it's not all Eureka moments. So you really need to find the right thing to work on. For some people it's roundworms or slugs; for others it's supernovae. I was lucky enough to find the one that fits me."

Turner embarked on this intellectual odyssey more than a quarter century ago and has no doubt that thrilling journeys still await him. To some people, the unresolved issues of cosmology — such as the mass of neutrinos, the existence of axions, or the origin of the asymmetry between matter and antimatter — are as esoteric as they come. Yet Turner insists these questions are indeed relevant, thus satisfying the concerns that loomed so large for him in the early 1970s. "I've learned there are lots of ways of being relevant," he says. "There are many people on this planet, and not everyone can be saving lives. Someone has to be out there figuring out our place in the universe."

Learn more about Turner's passion for cosmology at www.astronomy.com/toc

BY MARTIN RATCLIFFE AND ALISTER LING

APRIL 04

The naked-eye planets line up in the evening sky while two comets put on nice shows — C/2002 T7 (LINEAR) glows brightly at dawn and C/2001 Q4 (NEAT) cracks the evening sky at month's end.

Venus meets the Pleiades

Perhaps no word better describes the evening sky in spring than "glorious." As twilight deepens, the greatest concentration of bright stars in the entire sky gathers in the southwest. This year, three bright planets top off the scene to create a truly special show. ☾ But there's more. All five naked-eye planets are visible simultaneously during April's first week. You'll need to hurry, however, because Mercury whips around the Sun and won't hang around. Look for it one binocular field above the western horizon 45 minutes after sunset. No bright stars lie in the area to confuse you.

Venus blazes brilliantly in the western sky after sunset and is by far the brightest point of light in the sky. But the highlight of the month arrives when Venus teams up with the sky's most delightful star group, the Pleiades (M45). From April 1 to 4, Venus lies a degree or less away from the magnificent cluster. Binoculars provide the best view of the conjunction. A telescope yields a close-up look at the planet, which this month grows noticeably as its phase wanes to a crescent.

VENUS PASSES NEAR THE PLEIADES in early April, mimicking the beautiful conjunction from April 1980 seen here. BRIAN TKACHYK

The orange "star" to the upper left of Venus is Mars. The Red Planet surely will disappoint anyone who looks at it through a telescope because its disk now appears so tiny. In contrast, the planet's motion across the sky is something to behold. Mars starts April directly to the right of Taurus's red eye, Aldebaran, and in just one month climbs nearly two-thirds of the way to Saturn. You can watch Mars fade by comparing it with Aldebaran.

Yellowish Saturn comes next in line. Take a good look through a telescope at the shadow cast on the rings by the disk — it creates a strong three-dimensional effect. Can you tell which limb the Sun rises on? It's the side that has a softer light. Next month will be your last chance to get a good view of Saturn until it returns to the dawn sky this autumn.

Jupiter shines brightly high in the southeast. The giant planet rewards patient telescopic observers with lots of detail. The longer you look, the more you'll see — it takes time to train your brain to discern detail. Perhaps this will be the year when the Great Red Spot returns to a darker color.

A slender crescent Moon joins the evening lineup starting on April 20 and threads the gap between Venus and Mars on the 23rd. Watch how the triangle formed by Venus, the Moon, and Mars changes shape over just a couple hours. The beautiful scene will be worth trying your hand at time-exposure or time-lapse photography.

After a long buildup, it's finally show time for the spring comets. For more than a year we've been waiting for two comets — C/2002 T7 (LINEAR) and C/2001 Q4 (NEAT) — to blaze across our skies. Will they be as bright as forecast, perhaps 2nd magnitude, or will they have fizzled? Maybe one will surprise us by sprouting energetic jets of dust and gas. Even planetary scientists don't know for sure what will happen.

What we do know is where they are. C/2002 T7 emerges low in the east during morning twilight around mid-April. After it swoops around the Sun, it will reappear in the evening sky in late May. C/2001 Q4 should be a showpiece all month for Southern Hemisphere observers; it then swings rapidly northward for the rest of us to see in late April and May.

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** NexStar 9.25 GPS shown with these optional accessories: Equatorial Wedge (#93655), Radial Guider (94176), and MicroGuide Reticle Eyepiece (#94171). Camera not included.
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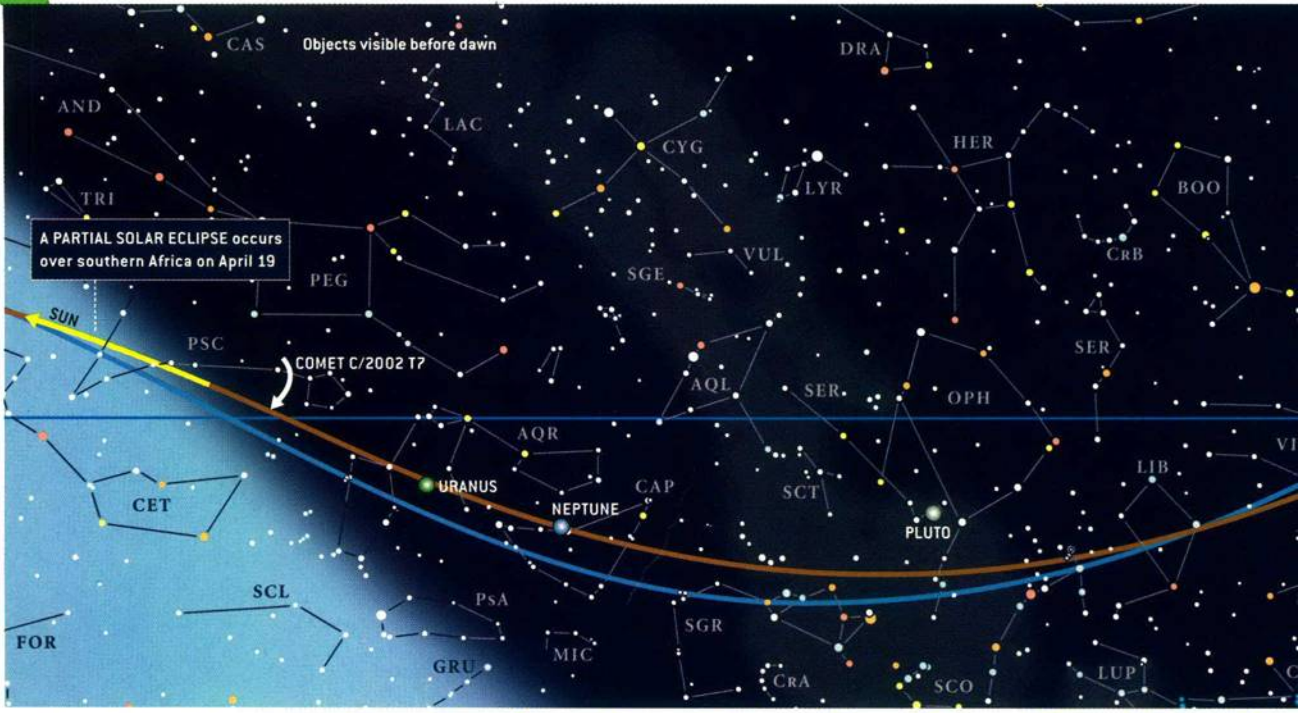
Eyepiece	1.25" 40mm Plössl (51x)	1.25" 40mm Plössl (59x)	1.25" 40mm Plössl (70x)
Finderscope	9x50	9x50	9x50
AC Adapter***	Included	Included	Included
Tripod	Heavy-Duty Adjustable	Heavy-Duty Adjustable	Heavy-Duty Adjustable
Fastar Compatible	Yes	No	No
Mirror Coatings	StarBright®, 5-step multi-layer	StarBright®, 5-step multi-layer	StarBright®, 5-step multi-layer
Telescope Weight	42 lbs	58 lbs	65 lbs.
Price*	**$2169**	**$2799**	**$3224**
StarBright XLT*	**$2324**	**$3019**	**$3504**
Shipping & Handling	$95	$115	$125

Planets this month

This map unfolds the entire night sky from sunset (at right) until sunrise (at left). Arrows and


Objects visible before dawn
CAS
AND
TRI
LAC
CYG
DRA
HER
LYR
BOO
A PARTIAL SOLAR ECLIPSE occurs over southern Africa on April 19
PEG
SGE
VUL
CRB
SUN
PSC
COMET C/2002 T7
AQL
SER
OPH
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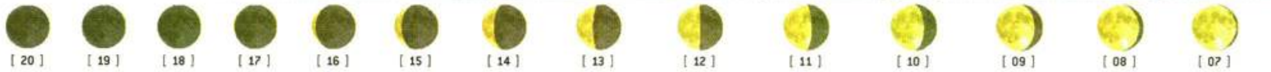
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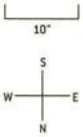
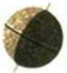
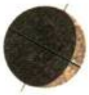
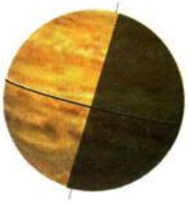
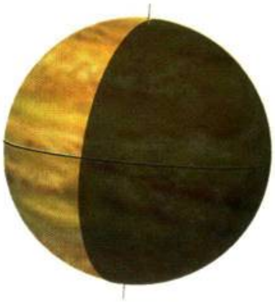
To locate the Moon in the sky, draw a line from the phase shown for the day s







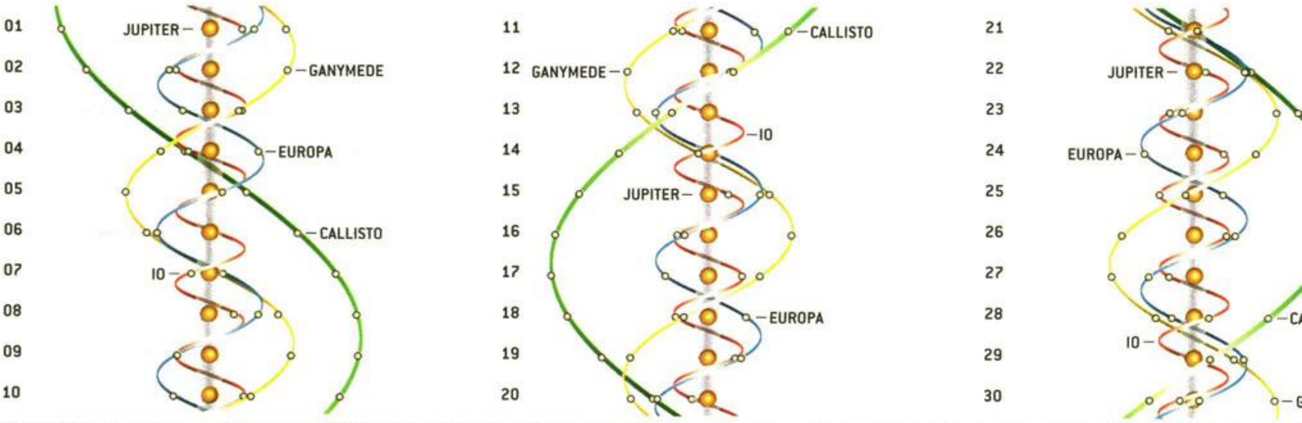




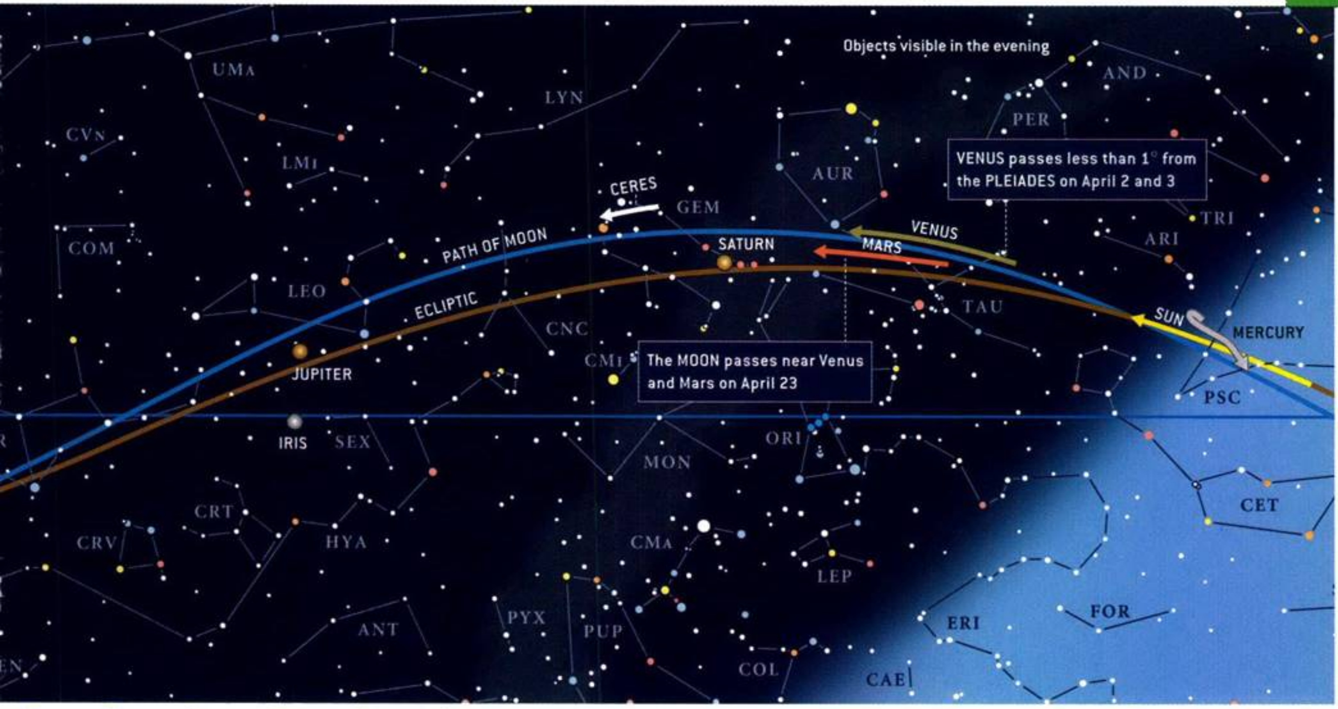
PLANETS	MERCURY	MERCURY	VENUS	VENUS
Date	April 1	April 30	April 1	April 30
Magnitude	0.4	2.0	−4.4	−4.5
Angular Size	8.1"	10.8"	24.1"	35.5"
Illumination	32%	14%	50%	30%
Distance (AU) from Earth	0.827	0.623	0.691	0.470
Distance (AU) from Sun	0.340	0.464	0.719	0.721
Right Ascension (2000.0)	1h47.0m	1h20.3m	3h37.4m	5h17.6m
Declination (2000.0)	14°07'	6°47'	22°50'	27°42'

Jupiter's moons

Dots display positions of Galilean satellites at 11 P.M. EDT on date shown. South is at top to match the view in a telescope



colored dots show motions and locations of solar system objects during the month.


Objects visible in the evening

VENUS passes less than 1° from the PLEIADES on April 2 and 3

The MOON passes near Venus and Mars on April 23

UMA
LYN
CVN
LMI
AND
PER
AUR
CERES
GEM
TRI
ARI
COM
PATH OF MOON
SATURN
VENUS
MARS
LEO
ECLIPTIC
TAU
SUN
MERCURY
CNC
CMI
JUPITER
PSC
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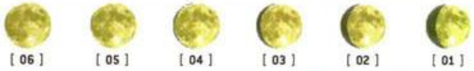
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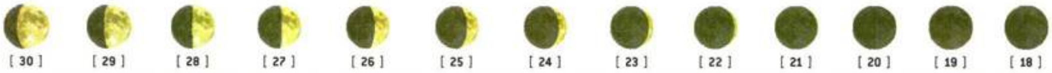
raight up to the curved blue line.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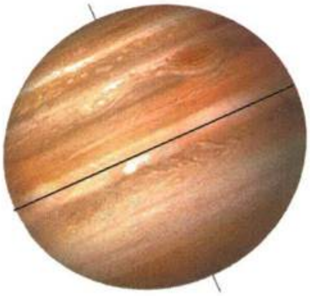
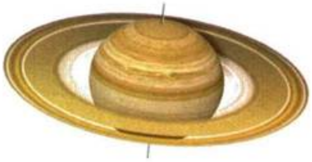
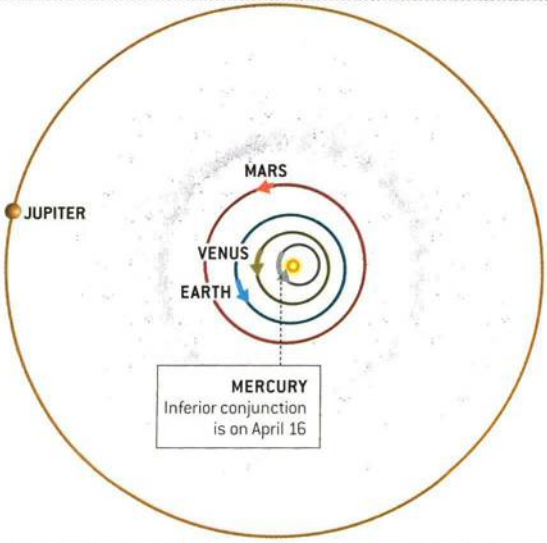




MARS	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
April 15	April 15	April 15	April 15	April 15	April 15
1.5	−2.3	0.1	5.9	7.9	13.8
4.6"	42.1"	17.9"	3.4"	2.2"	0.1"
94%	100%	100%	100%	100%	100%
2.044	4.678	9.293	20.677	30.396	30.227
1.604	5.425	9.038	20.044	30.072	30.782
4h57.4m	10h46.3m	6h32.8m	22h30.3m	21h10.1m	17h27.6m
23°51'	9°18'	22°48'	−10°11'	−16°22'	−14°20'

e.

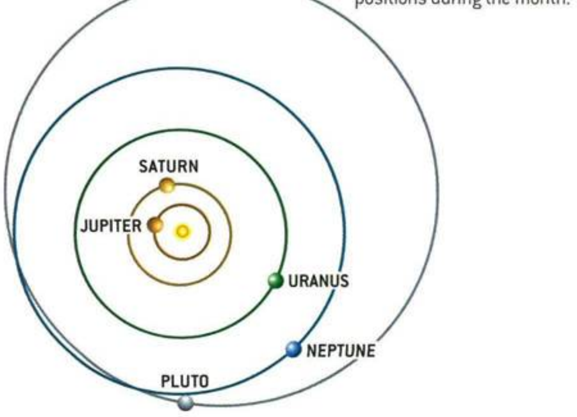
LLISTO
ANYMEDE


JUPITER
MARS
VENUS
EARTH

MERCURY
Inferior conjunction is on April 16

The planets in their orbits

Arrows and dots show planets' positions during the month.


SATURN
JUPITER
URANUS
NEPTUNE
PLUTO

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- **11% more photons will be detected with a CCD camera using StarBright XLT coating system compared to UHTC coatings** (See Fig.#2)
- **6% brighter than UHTC to the dark-adapted eye** (See Fig.#3)
- **16% brighter than our standard StarBright coating across the spectrum from 400nm to 750nm.**

Coming Out of the Dark — StarBright XLT Performance Where It Counts

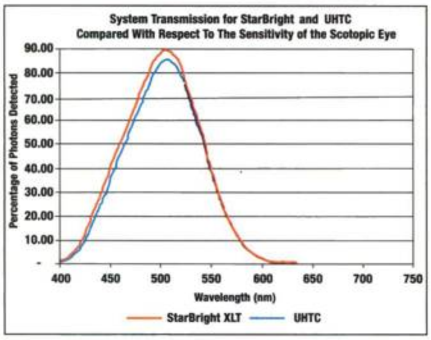

*Fig #3: The scotopic, dark adapted eye is most sensitive at about 510nm. The dark-adapted eye has nearly zero sensitivity below 400nm and above 650nm. This plot compares StarBright XLT and our measurement of UHTC taking into account the sensitivity of the human eye. The result is that StarBright XLT is a **6% improvement over UHTC** for visual observing .**

System Transmission At Specific Wavelengths — Celestron StarBright XLT vs UHTC

	Wavelength (nm)	StarBright XLT	UHTC Measured	Percent Improvement
H-beta	486	87.5	83.0	**5%**
Helium II and O_3	496	88.0	84.0	**5%**
O_3	501	88.0	84.3	**5%**
Center of dark adapted vision	510	88.7	84.8	**5%**
Helium I	588	88.0	81.6	**8%**
N_2	655	84.0	73.8	**14%**
N_2 and H-alpha	658	84.0	73.0	**15%**
Sulfur II	673	83.0	72.0	**15%**

System Transmission for StarBright XLT and UHTC

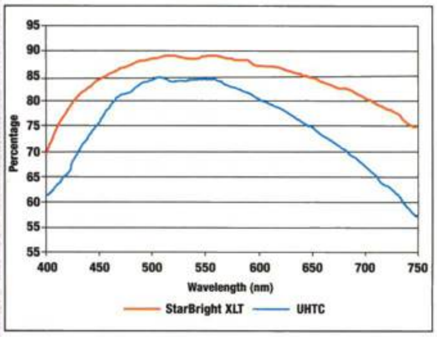

*Fig #1: This is a plot of measured system transmission for Celestron's StarBright XLT and UHTC coatings. The StarBright XLT coating has an overall average system transmission of 83.5% compared to UHTC at 75.1%. System transmission is determined by taking the measured value of the reflectance of the primary, times the reflectance of the secondary, times the transmission of the corrector lens.**

CCD Imaging — It's All In The Photons

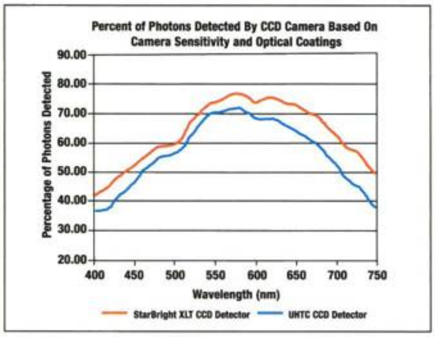

*Fig #2: StarBright XLT is not only optimized for visual use, it is also optimized for imaging. This plot takes into account the sensitivity of a popular CCD chip (KAK-3200 used in SBIG's ST10ME) in conjunction with the system transmission based on the optical coatings. Our measurements indicate that the CCD chip will detect 11% more photons with Celestron's StarBright XLT than UHTC.**

UHTC Coatings Don't Measure Up To StarBright XLT

In order to determine how our newly designed XLT performs compared to the competition, we tested several optical systems with UHTC coatings. All measurements have been conducted with spectrophotometers measuring light transmission of coated correctors and reflectance of coated mirrors. This allows us to compare the transmission of our correctors and the reflectance of our mirrors against those of the competition. To ensure the integrity, accuracy, and reliability of these test results, they have been independently verified. A detailed description of our testing process can be found on our website: **www.celestron.com/starbrightxlt**.*

****Percent differences are calculated by taking the comparison data percentage divided by the baseline data. Example: Measured average system transmission for UHTC is 75.1%. XLT average system transmission is 83.5%. 83.5% divided by 75.1% = 1.11 or 11% improvement. Measurement results are rounded to the nearest whole percentage.***

The StarBright XLT System — What makes it different makes it better. — There are three major components that make up our StarBright XLT high transmission optical system design:

1. **Unique enhanced multi-layer mirror coatings** — Our mirror coatings are made from precise layers of aluminum (Al), SiO_2 (quartz), TiO_2 (titanium dioxide), and SiO_2. Reflectivity is fairly flat across the spectrum, optimizing it for both CCD imaging and visual use.
2. **Multi-layer anti-reflective coatings** — Made from precise layers of MgF_2 (magnesium fluoride), and HfO_2 (hafnium oxide). A rare element costing nearly $2000 per kilogram, hafnium gives us a wider band pass than titanium, used in UHTC coatings.
3. **High transmission water white glass** — Celestron Schmidt-Cassegrain optical systems with **optional** StarBright XLT coatings use water white glass instead of soda lime glass for the corrector lens. ***Water white glass transmits about 90.5% without anti-reflective coatings.*** That is 3.5% better transmission than uncoated soda lime glass. ***When water white glass is used in conjunction with StarBright XLT's anti-reflective coatings, the average transmission reaches 97.4% — an 8% improvement!***

For more information about StarBright XLT visit: www.celestron.com/starbrightxlt

StarBright XLT Pricing

All 8" Schmidt-Cassegrain Products	**$125**
All 9.25" Schmidt-Cassegrain Products	**$175**
All 11" Schmidt-Cassegrain Products	**$225**
All 14" Schmidt-Cassegrain Products	**$275**

NEW 2003 PRODUCT GUIDE

To request a copy of Celestron's new 2003 Product Guide, contact us at (310) 328-9560.

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ACCESSORIES

FOR MORE INFORMATION OR TO LOCATE AN AUTHORIZED CELESTRON DEALER, VISIT: WWW.CELESTRON.COM

OMNI® Eyepieces — 1 1/4"

- Focal lengths – 4mm, 6mm, 9mm,12.5mm, 15mm, 20mm, 25mm, 32mm, and 40mm
- **4-element premium symmetrical optical design**
- Fully multi-coated
- 52° (43° for 40mm) Field of View
- 2-step anodize process to prevent reflection from top surfaces
- Blackened lens edges

NEW!

4mm	$ 44.00
6mm	$ 44.00
9mm	$ 44.00
12.5mm	$ 44.00
15mm	$ 44.00
20mm	$ 44.00
25mm	$ 44.00
32mm	$ 54.00
40mm	$ 54.00

NEW!

OMNI® Barlow Lens — 1 1/4"

- 2x
- Fully multi-coated
- Short tube design

1-1/4"OMNI Barlow............$ 47.00

X-Cel® Eyepieces — 1 1/4"

- **6-element optical design utilizing ED glass**
- Focal lengths – 2.3mm, 5mm, 8mm,10mm, 12.5mm,18mm, 21mm, and 25mm
- Fully Multi-coated. All air-to-glass surfaces have 5 layer multi-coating
- Field of view 55°
- Parfocal – little to no focusing adjustments are needed when switching from a low power to high power eyepiece
- 20mm eye relief and soft rubber roll down eyecups
- More than 25mm of clear aperture even on the high powers for comfortable high power viewing
- Each eyepiece comes with a durable plastic case

NEW!

2.3mm	$ 69.00	12.5mm	$ 69.00
5mm	$ 69.00	18mm	$ 69.00
8mm	$ 69.00	21mm	$ 69.00
10mm	$ 69.00	25mm	$ 69.00

NEW!

E-Lux® Eyepieces 2"

- Focal lengths – 26mm, 32mm, and 40mm
- 3-element optical design
- **Fully multi-coated**
- Field of View — 56° (26mm and 32mm), 50° (40mm)
- 22mm Eye Relief

E-Lux® Eyepieces — 1 1/4"

- Focal lengths – 6mm, 10mm, 25mm, and 40mm
- Traditional Plössl optical design
- Fully-coated

2":		1-1/4":	
26mm	$ 69.00	6mm	$ 34.00
32mm	$ 69.00	10mm	$ 34.00
40mm	$ 79.00	25mm	$ 34.00
		40mm	$ 34.00

Axiom® Eyepieces — 1 1/4", 2"

- Focal lengths –
  1-1/4": 15mm, 19mm, 23mm
  2": 19mm, 34mm, 40mm, and 50mm
- **7-element optical design**
- **70° EXTRA WIDE** field of view (except 50mm)
- Fully multi-coated

1-1/4":	
15mm	$139.00
19mm	$149.00
23mm	$179.00
2":	
19mm	$189.00
34mm	$239.00
40mm	$289.00
50mm	$329.00

Ultima® Eyepieces — 1 1/4"

- **5-element hybrid optical design**
- Focal lengths – 5mm, 7.5mm, 12.5mm, 18mm, 30mm, 35mm, and 42mm
- Fully multi-coated
- Blackened lens edges

5mm	$ 79.00
7.5mm	$ 79.00
10mm	$ 79.00
12.5mm	$ 79.00
18mm	$ 79.00
30mm	$ 99.00
35mm	$109.00
42mm	$ 99.00

10mm Plössl Reticle Eyepiece — 1 1/4"

- Five-element guiding eyepiece
- Reticle pattern is a .0075" double spaced line system
- Multicoated optics for increased contrast
- Long eye relief
- High power is ideal for guiding
- 50° apparent field of view
- Optional illuminator is required

10mm Plössl Reticle Eyepiece —11/4"............$124.00

Stereo Binocular Viewer

- Allows you to adapt two eyepieces to the telescope for simultaneous viewing (like binoculars)
- A fantastic 3-D effect when observing many celestial objects

Stereo Binocular Viewer.......$649.00

Filter & Eyepiece Kit

- Five Superior Grade Plössl Eyepieces — 1.25"
- Barlow Lens — 2x 1.25"
- Six Colored Eyepiece (Planetary) Filters
- Moon Filter — 1.25"
- Aluminum Carrying Case

Filter & Eyepiece Kit.......$ 99.00

Ultima® 2x Barlow — 1 1/4"

- **Three-element apochromatic design**
- 27mm clear aperture
- Fully multi-coated

1-1/4"Ultima Barlow.......$ 79.00

Microguide Eyepiece — 1 1/4"

- Laser-etched reticle with a built-in, battery illuminator
- Multicoated 12.5mm Abbe (4-element) Orthoscopic
- Direct guiding on stars outside the center of the field of view
- Greatly improved off-axis guiding to capture much fainter, sharply focused guide stars without reducing limiting magnitude
- Measure position angles and separation of double stars

Microguide Eyepiece 1-1/4".......$194.00

Collimation Eyepiece

- For precise collimation of Newtonians and helpful for aligning Schmidt-Cassegrains
- Fits into 1-1/4" focusers or diagonals
- Alignment is easy using the small opening on one end and thin cross hairs at the other end
- More accurate than a simple collimation Tool

Collimation Eyepiece.......$ 39.00

Radial Guider

- Use with Schmidt-Cassegrain telescopes in prime focus, deep-sky imaging or astrophotography
- Simultaneously photograph and guide through the optical tube assembly of the telescope
- Adjustable prism and rotating eyepiece collar give wider section of sky for finding a guide star
- Eliminates the problem of differential flexure

Radial Guider.......$124.00

Reducer/Corrector

- Works with all Celestron C5, C8, C9-1/4 , C11 and C14 telescopes
- Minimizes coma and flattens field of view for pinpoint off-axis stars
- Reduces exposure times by 60% and increases field of view
- f/6.3 for C5, C8, C91/4 and C11 telescopes and f/7 for the C14 telescope

Reducer/Corrector.......$139.00

2" Mirror Diagonal

- 2" 90° Mirror Diagonal to thread on Schmidt-Cassegrain telescopes
- Includes an adapter to use with refractor telescopes
- Includes an adapter to accept 1 1/4" eyepieces
- Multicoated mirror
- Smooth mechanics that are precision manufactured for reliability

2" Mirror Diagonal.......$ 89.00

Power Tank™

- 12-volt rechargeable power supply
- 7-amp hour
- Two 12V output cigarette lighter ports
- 3V, 6V and 9V outputs for accessories
- Built-in flashlight with red filter cap
- 800,000 candle power halogen emergency spotlight
- Booster terminal on rear side
- Built-in circuit breaker for safety
- Cigarette lighter adapter included
- AC adapter included (120V-220V)

NEW!

Power Tank............$ 69.00

Vibration Suppression Pads

- Reduces vibration time by almost 100% and decreases vibration amplitude
- The pads fit between the bottom of the tripod legs and the ground

Vibration Suppression Pads (Set of 3)............$ 59.00

Contrast-Booster Filter — 1 1/4"

by Baader

- Eliminates color aberration inherent in achromatic refractor telescopes
- Eliminates the blue hue around lunar and planetary subjects
- Multi-layer coatings for 95% transmission

NEW!

1-1/4" Contrast - Booster Filter............$ 49.00

Model A — for 1-1/4" eyepieces **Model B — for backthreads of SC's**

LPR (Light Pollution Reduction) Filters

- Made of high quality, flat polished optical glass
- Over 40 layers of coating
- Broadband anti-reflection coating prevents ghosting and improves contrast

LPR Filter — 1-1/4"	$ 69.00
LPR Filter Model B	$ 99.00

1 1/4" Polarizing Filter Set

- Transmits only light moving along a specific plane; increases contrast between surfaces with different planar transmissions
- Polarization effect makes blue skies a deeper blue, eliminates surface reflections and helps reduce atmospheric haze

1-1/4" Polarizing Filter Set......$ 39.00

Eyepiece Filter Sets — 1 1/4"

- An invaluable aid in planetary and lunar observing
- Reduces glare and light scattering
- Increase contrast, definition and resolution
- Lessens eye fatigue

#94119-10 (21, 80A, 15, Polarizing)	$ 44.00
#94119-20 (12, 25, 56, ND-25)	$ 44.00
#94119-30 (23A, 38A, 58, ND-50)	$ 44.00
#94119-40 (8, ND-13, 47, 82A)	$ 44.00

Night Vision Flashlight

- Two red LEDs
- Adjustable brightness
- Uses a single 9V battery (included).

Night Vision Flashlight.......$ 19.00

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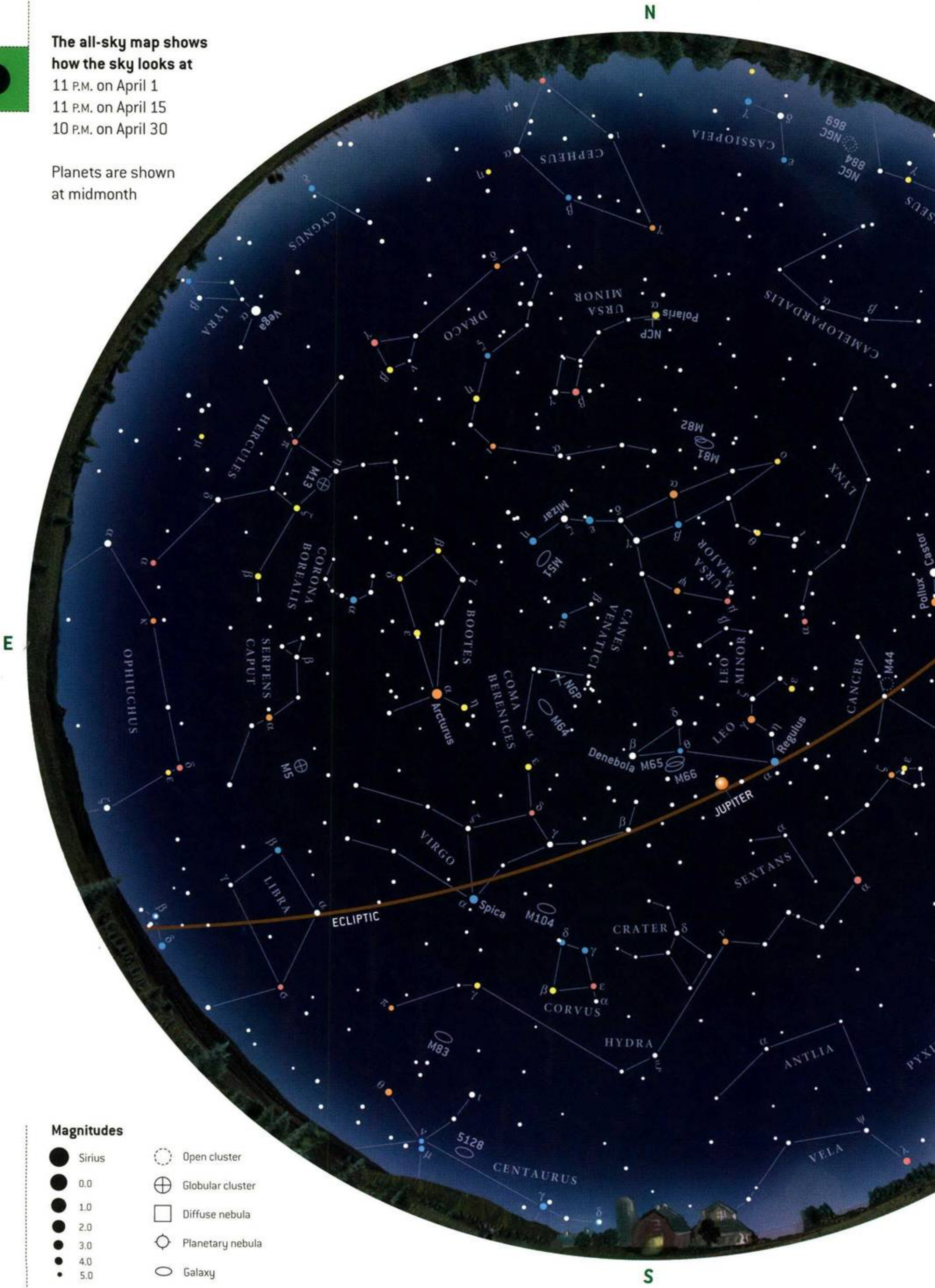
Note: All prices shown are suggested mail-order.
All prices shown in U.S. Dollars.

The all-sky map shows how the sky looks at
11 P.M. on April 1
11 P.M. on April 15
10 P.M. on April 30

Planets are shown at midmonth


N
S
E
CEPHEUS
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NGC 884
PERSEUS
CYGNUS
LYRA
Vega
DRACO
URSA MINOR
Polaris
NCP
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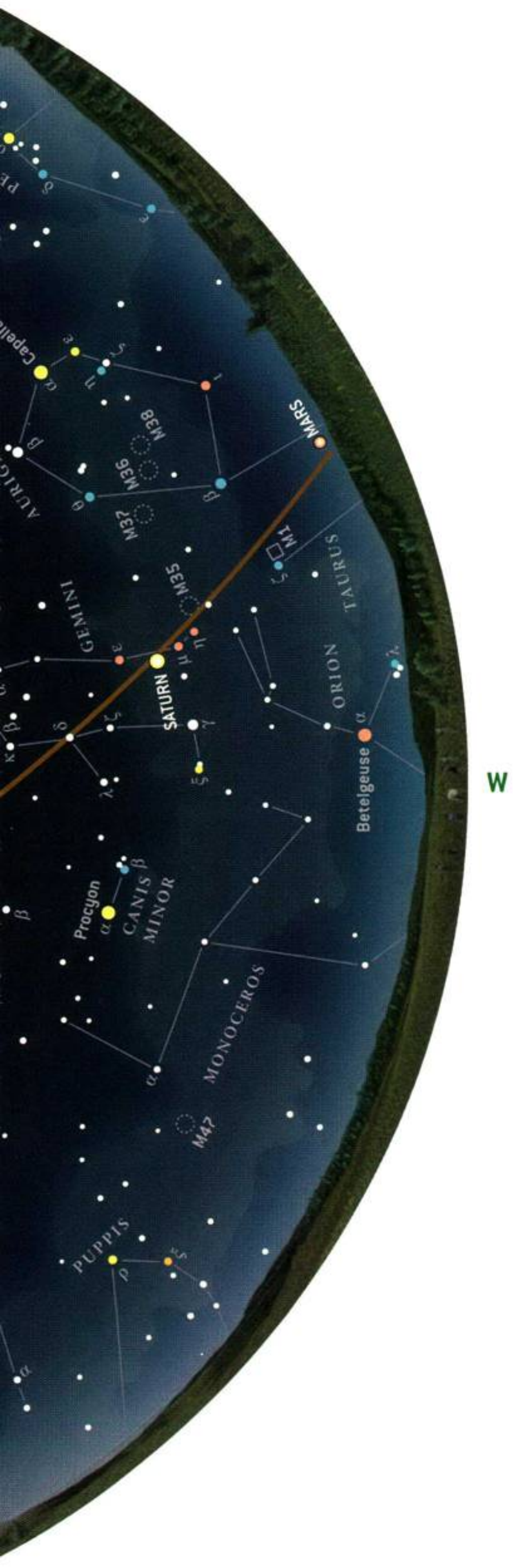
HERCULES
M13
M82
M81
LYNX
Mizar
M51
URSA MAJOR
CORONA BOREALIS
BOOTES
CANES VENATICI
LEO MINOR
Castor
Pollux
OPHIUCHUS
SERPENS CAPUT
COMA BERENICES
NGP
M64
M44
CANCER
Arcturus
LEO
Regulus
Denebola
M65
M66
M5
JUPITER
VIRGO
SEXTANS
LIBRA
Spica
M104
ECLIPTIC
CRATER
CORVUS
HYDRA
M83
ANTLIA
PYXIS
5128
CENTAURUS
VELA
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

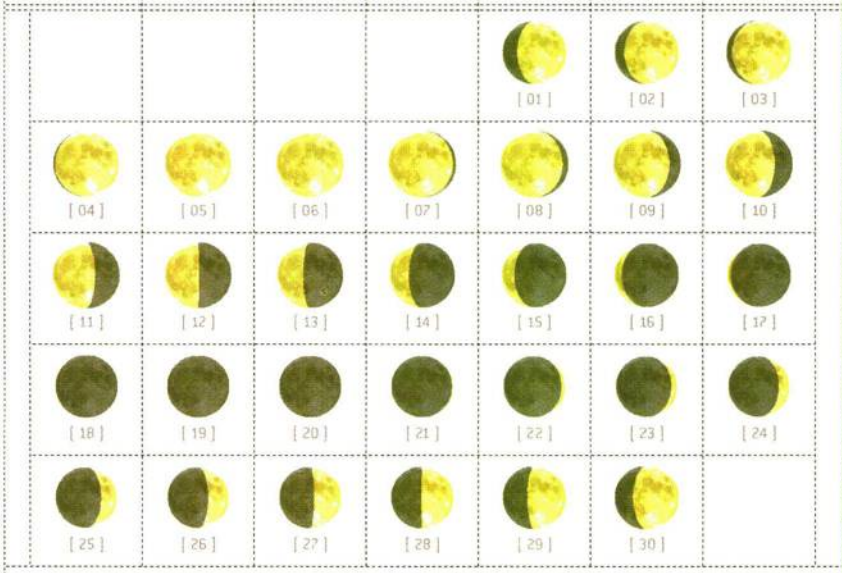
This map portrays the sky as seen near 35° north latitude at times shown in the upper left corner of the page. Located just outside the map are the four directions: nor

horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.


Capella
AURIGA
M38
M36
M37
MARS
M1
M35
GEMINI
TAURUS
ORION
SATURN
Betelgeuse
Procyon
CANIS MINOR
MONOCEROS
M47
PUPPIS
W

h, south, east, and west. To find stars above your

april 04



SUN.	MON.	TUES.	WED.	THURS.	FRI.	SAT.
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[25]	[26]	[27]	[28]	[29]	[30]	

02 The Moon passes 3° north of Jupiter, 2 P.M. EST

05 Full Moon is at 7:03 A.M. EDT

07 Mars passes 7° north of Aldebaran, 1 A.M. EDT

The Moon is at perigee (226,519 miles from Earth), 10:25 P.M. EDT

11 Last Quarter Moon is at 11:46 P.M. EDT

13 The Moon passes 5° south of Neptune, noon EDT

14 The Moon passes 4° south of Uranus, midnight EDT

16 Venus passes 10° north of Aldebaran, 6 A.M. EDT

Mercury is in inferior conjunction, 9 P.M. EDT

19 New Moon is at 9:21 A.M. EDT; partial solar eclipse

21 Lyrid meteor shower peaks

23 The Moon passes 1.5° south of Venus, 6 A.M. EDT

The Moon passes 2° north of Mars, 5 P.M. EDT

The Moon is at apogee (251,906 miles from Earth), 8:25 P.M. EDT

25 The Moon passes 5° north of Saturn, 2 A.M. EDT

27 First Quarter Moon is at 1:32 P.M. EDT

29 The Moon passes 4° north of Jupiter, 10 P.M. EDT

To design the perfect telescope family for the beginner or advanced user, you have to think BIG.

C6-RGT
[#11046]

C8-S/C8-SGT/C9$^{1/4}$-S/C9$^{1/4}$-SGT NOW AVAILABLE WITH OPTIONAL

StarBright XLT
HIGH PERFORMANCE OPTICAL SYSTEM

8" Advanced Series Schmidt-Cassegrain Products.......$125

9$^{1/4}$" Advanced Series Schmidt Cassegrain Products...............$175

For more information, visit:
www.celestron.com/starbrightxlt

The new Advanced Series and Advanced Series **Computerized GoTo** telescopes have been designed to offer the novice or more advanced user a selection of models with the **features, quality** and **value** that serious amateurs can appreciate. These scopes come on **NEW heavy-duty German Equatorial mounts** with **NEW ultra-sturdy 2" stainless steel legs** and center brace and accessory tray for superior stability, rigidity and vibration dampening. The Advanced Series comes in a choice of refractor, reflector and Schmidt- Cassegrain models. The refractor models range from a 4" to an impressive 6" aperture. For even more light gathering power there are 6", 8" and a **NEW 10" Newtonian** reflector. There are also 5", 8" and 9 1/4" Schmidt-Cassegrain optical designs that feature Celestron's **precision matched and hand-figured optical systems.**

Auxiliary ports for Hand Control, Dec Motor and AutoGuider.

CG-5 Mount — Precision engineered for stability.

Additional Specifications — Computerized Models

Hand Control	Double line, 16 character Crystal Display; 19 fiber optic backlit LED buttons
Motor: Type	DC Servo motors with encoders, both axes
Max Slew Speed	4°/second
Software Precision	24bit, 0.08 arcsec calculation
Hand Control Ports	RS-232 communication port on hand control
Motor Ports	Aux Port, Autoguide Ports
Tracking Rates	Sidereal, Solar and Lunar
Tracking Modes	EQ North & EQ South
Alignment Procedures	AutoAlign, 2-Star Alignment, Quick Align
Database	40,000+ objects, 400 user defined programmable objects

Our **new CG-5 German Equatorial Mount** has precision worm gears on both axes for extremely smooth tracking and slewing. The CG-5 uses large shaft and bearings and substantial base castings for additional stability. The key element that makes this system the most stable in its class is the **NEW heavy-duty tripod** with **larger and more substantial legs** that provide excellent damping characteristics for more stable views. The CG-5 also has a convenient **latitude scale** for easier alignment and an **optional polar finder scope** for the ultimate in precision alignments.

C9$^{1/4}$-SGT
[#11046]

GoTo convenience and GPS compatibility for precision accuracy.

We are proud to offer the GT versions of the Advanced Series on a computerized **GoTo** version of Celestron's sturdy CG-5 mount. Couple this solid mount with the included **NexStar® computer control system** and utilize many of the same features as Celestron's most advanced GoTo telescopes like an **Autoguider port** for long exposure deep sky astro-photography. **GoTo models are also upgradeable to GPS** with the optional **CN16 GPS Accessory (#93963).** It allows your telescope to pinpoint your position on the Earth, the date and time, and makes the alignment process faster and easier than ever before!

C10-NGT
[#11048]

These GoTo versions of the Advanced Series also come loaded with new software features and **over 40,000 database objects**. Capable of holding over 35 lbs of payload and slewing at 4° per second, you will be able to instantly point to any of the celestial objects in the database.

NEW 2003 PRODUCT GUIDE

To request a copy of our new 2003 Product Guide, contact us at (310) 328-9560.

Specifications — All Advanced Series Telescopes

	21016 C4-R	11071/11072 C5-S	31056 C6-N	21019/21020 C6-R	11025/11024 C8-S	31061/31062 C8-N	11045/11046 C9 1/4-S	11047/11048 C10-N
Optical Design	102mm (4.0") refractor	127mm(5") Schmidt-Cassegrain	150mm (6.0") reflector	150mm (6.0") refractor	203mm (8") Schmidt-Cassegrain	200mm (8.0") reflector	235mm (9.25") Schmidt-Cassegrain	254mm (10") reflector
Focal Length	1000mm f/10	1250mm f/10	750mm f/5	1200mm f/8	2032mm f/10	1000mm f/5	2350mm f/10	1200mm f/4.7
Finderscope	6x30	6x30	6x30	9x50	6x30	9x50	6x30	9x50
Mount	CG-4 Equatorial	CG-5 Equatorial	CG-4 Equatorial	CG-5 Equatorial	CG-5 Equatorial	CG-5 Equatorial	CG-5 Equatorial	CG-5 Equatorial
Eyepiece	1-1/4" – 20mm (50x)	1-1/4" – 25mm (50x)	1-1/4" – 20mm (38x)	1-1/4" – 20mm (60x)	1-1/4" – 25mm (81x)	1-1/4" – 20mm (50x)	1-1/4" – 25mm (94x)	1-1/4" – 20mm (60x)
Star Diagonal	1-1/4"	1-1/4"	n/a	1-1/4"	1-1/4"	n/a	1-1/4"	n/a
Accessory tray	yes	yes	yes	yes	yes	yes	yes	yes
Tripod	Aluminum	2" Stainless Steel	Aluminum	2" Stainless Steel	2" Stainless Steel	2" Stainless Steel	2" Stainless Steel	2" Stainless Steel
CD ROM	The Sky Level 1	The Sky Level 1	The Sky Level 1	The Sky Level 1	The Sky Level 1	The Sky Level 1	The Sky Level 1	The Sky L1

PRICING*: C10-NGT (#11048): $1,149 + $95 S&H; C10-N (#11047):$849 + $75 S&H; C9$^{1/4}$-SGT (#11046): $1,699 + $105 S&H; C9$^{1/4}$-S (#11045): $1,399 + $85 S&H; C8-SGT (#11026): $1,299 + $75 S&H; C8-S (#11025): $999 + $85 S&H; C8-NGT (#31062): $949 + $85 S&H; C8-N (#31061): $649 + $65 S&H; C6-RGT (#21020): $999 + $95 S&H; C6-R (#21019): $799 + $75 S&H; C6-N (#31056) $399 +$50 S&H; C5-SGT (#11072): $1,099 + $75 S&H; C5-S (#11071): $849 + $65 S&H; C4-R (#21016): $399 + $40 S&H

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*Prices shown are U.S. mail order.

THE DEEP SKY

Known to observers around the world, the magnificent Pleiades star cluster features prominently in almost every culture's mythology.

Subaru's Seven Sisters

Unsurpassed in beauty, the bright, twinkling group of stars known as the Pleiades (M45) now perches above the western horizon after darkness falls. The name *Pleiades* comes to us from Greek mythology, but it shouldn't be a surprise that cultures around the globe also have latched on to this wonderful cluster.

Unless you're familiar with Japanese mythology, the name Subaru probably brings to mind a car. You even may have noticed that the company's logo features a group of stars. A quick look might have you thinking: "It looks like the Pleiades, but artistic license seems to have adorned it with a supernova." Yet it turns out this beacon may have been the planet Venus.

On April 2, binoculars will reveal a sight remarkably similar to the logo — except the first-hand experience will prove immeasurably more inspiring. By the 5th, the magic will have gone as the separation between the planet and cluster increases.

You probably will notice a couple discrepancies between the logo and reality: Venus appears on the wrong side of the Pleiades in the real sky, and the mini-dipper shape lies on its side. Interestingly, our current view almost exactly matches the celestial positions seen four years before the Subaru car company was founded in 1968.

Martin Ratcliffe *is former president of the International Planetarium Society.* **Alister Ling** *is a meteorologist for Environment Canada.*

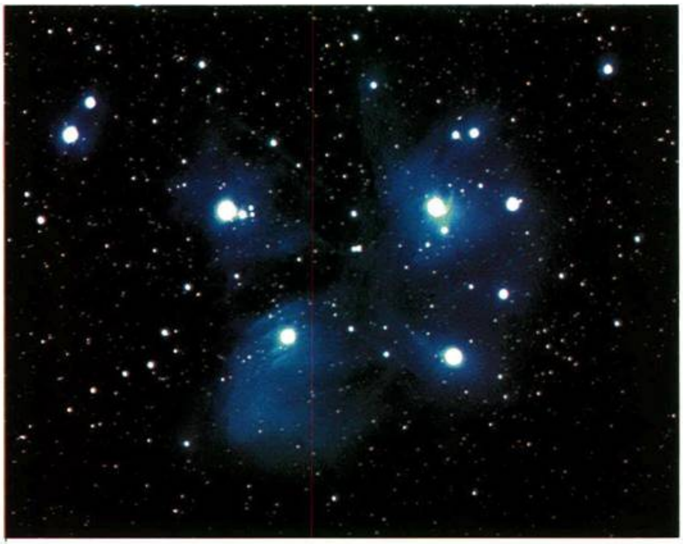
The Pleiades first appeared in print in Chinese annals of 2357 B.C., and today, Subaru takes part in the Japanese Feast of Lanterns, which according to tradition, marks the time when the souls of the dead return to visit their relatives. Even in ancient Japan, Subaru was imagined in different ways: as seeds by farmers and as a net by fishermen.

In commemoration of the star cluster, the 8-meter Japanese telescope at the summit of Mauna Kea in Hawaii was named Subaru.

How many do you see?

If you see only a fuzzy blob when you look at the Pleiades, it's time for a trip to the eye doctor. You'll be amazed at what you can see with sharp vision. Most people can count five stars pretty easily. The 6th, Taygeta, proves a little tougher, lying just off the upper right tip of the mini-dipper shape. The 7th, Pleione, is just above the handle star, Atlas. Some people blessed with great vision can spy 10 to 13 stars in all. The trouble isn't that these extra stars are faint, but that they lie in the glare of the brighter ones.

A little-known trick may help increase your star count: seek out the cluster while the sky shows some twilight. Dawn works best because you're coming out of darkness, but evening twilight will do. (In the latter case, use binoculars to first latch onto the position of the group.) As dawn progresses, there will come a time when the sky grows light enough to cause your pupil to contract a bit. This often sharpens the view. Additionally, the brightest Pleiads — Alcyone, Atlas, Electra, and Maia — will no longer cause glare. Suddenly, the fainter ones pop into view. Unfortunately, this technique does not work from a large city, where light pollution totally washes out the fainter stars.



THE PLEIADES STAR CLUSTER (M45) ranks as the brightest Messier object and one of the most beautiful sights whether viewed through binoculars or a telescope. TONY AND DAPHNE HALLAS

Wispy streaks

Detailed photographs reveal the delicate tendrils of a dusty reflection nebula enshrouding the Pleiades. For a long time, astronomers thought this material represented the remnants of the cluster's birth cocoon, but not so. Known as the Merope Nebula (NGC 1435), this cloud actually belongs to a huge complex of gas and dust that the Pleiades just happens to be passing through. The dust reflects the light of the blue-white stars, giving the nebula this characteristic color. The largest and brightest section of the nebula heads south from Merope and can be glimpsed with binoculars under a dark sky. Make sure the lenses are clean and there's no haze in the sky. Then check your observation against the nearby Hyades cluster. If that shows nebulosity, you'll know the "nebula" you're seeing resides in the optics.

THE PLANETS

All five naked-eye planets appear in the evening sky during the first week of April. They should provide splendid views to observers of all stripes.

Planets, planets, everywhere. That pretty much sums up the appearance of the evening sky in April. Mercury, Venus, Mars, Saturn, and Jupiter — in that order from west to east — will be on display throughout the first week of the month. Saturn, in particular, will garner increased interest as more spectacular images are returned from the Cassini spacecraft. Cassini will reach the ringed planet on July 1.

Closest to the horizon after sunset is **Mercury**. It spent the last two weeks of March visible in the western twilight and remains bright in early April. On April 1, the planet appears 11° high 30 minutes after sunset and sets about 90 minutes after the Sun. A telescope will show Mercury as a crescent disk measuring 8.1" across. Mercury's orbital path soon will carry it between the Sun and Earth, and the innermost planet disappears from the evening sky by the end of April's first week.

Venus dominates the early evening sky, reaching magnitude –4.5 by the end of the month. That's far brighter than any other planet or star. Its distance shrinks to half an astronomical unit this month, bringing Venus within approximately 45 million miles of Earth. This relative proximity makes Venus look big through a telescope. Its apparent size grows from 24" to 36" during April while its phase shrinks from half-lit to a crescent. Venus sets four hours after the Sun in mid-April and stands 25° above the western horizon once the sky has grown dark.

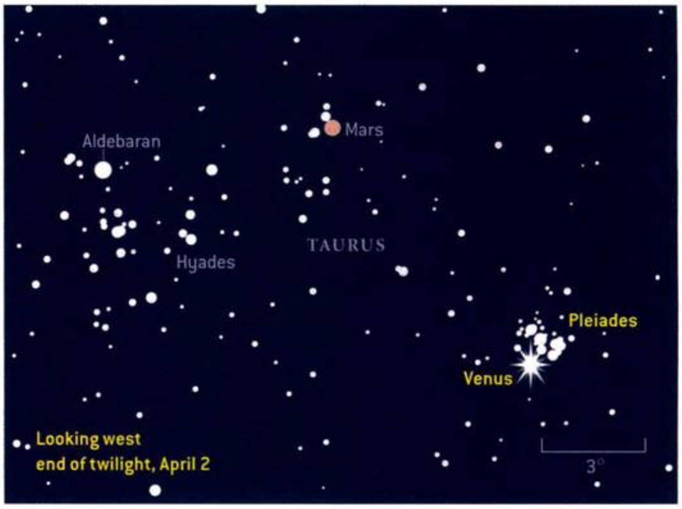
Don't miss the juxtaposition of Venus and the Pleiades star cluster (M45) on the evenings of April 2 and 3. This spectacular pairing brings Venus less than 1° away from the famous cluster, the brightest object in the Messier catalog. If you have a camera capable of taking time exposures, try to capture the scene.

On the same two nights, **Mars** lies 9° higher in the sky than Venus and due north of Taurus the Bull's other prominent star cluster, the Hyades. More than two hundred times fainter than Venus, Mars is a dwindling ember at magnitude 1.4. Nearby Aldebaran, the well-known star that marks the eye of the celestial Bull, shines noticeably brighter at magnitude 0.9.

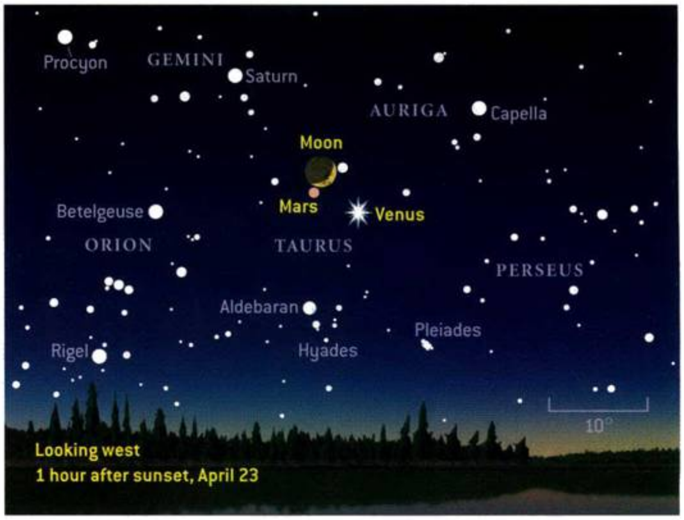
Keep watching after April 3 as Venus climbs away from M45, as if trying to catch up with Mars. Mars has its own ideas, however, and continues to move along the ecliptic between the horns of the Bull. By April 9, Venus lies roughly where Mars was a week earlier, north of the Hyades. The planets' separation has diminished by then to 7°.

Venus and Mars continue to close — and a sequence of nightly photographs will illustrate this very well. The next good photogenic events happen on April 22 and 23, when the crescent Moon passes by the planets. On the 22nd, a three-day-old Moon lies 5° below Venus with Mars the same distance to Venus's upper left. The following night, the Moon lies 3° above Mars. Shoot the scenes on film or with a digital camera with some twilight and a tree or other interesting object in the foreground. Such images don't do justice to the beauty of the naked-eye view, but they will be wonderful keepsakes of these conjunctions.

One night later, **Saturn** stands 5° to the left of the waxing crescent Moon. April ends with Mars and Venus 6° apart and Saturn lying 13° east of Mars. These three planets are lining up for a fine conjunction in May.



Looking west
end of twilight, April 2



Looking west
1 hour after sunset, April 23

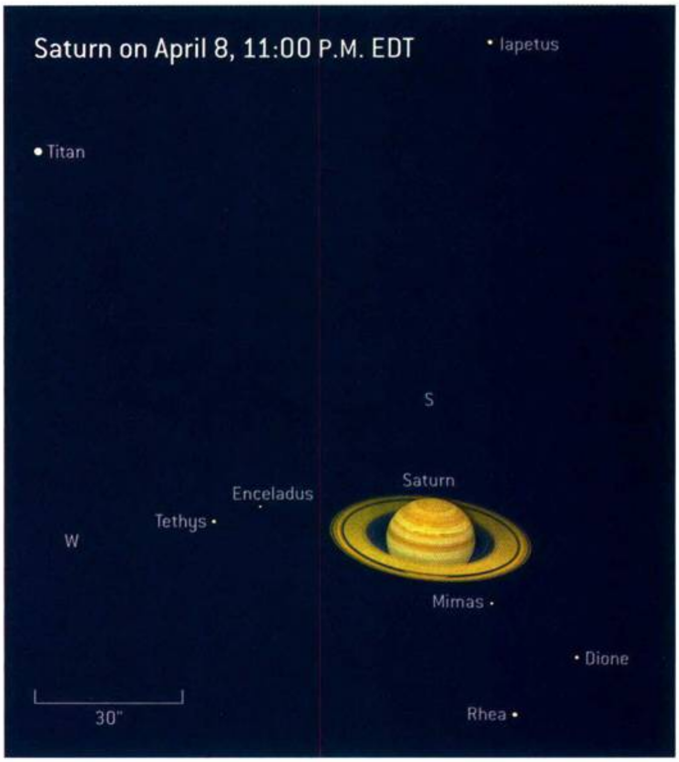
Another object also is heading toward Saturn, but this one's too small to be seen. The Cassini spacecraft, which was launched in 1997, used the gravitational pull of several planets to slingshot its way toward Saturn. Now on the final leg of its arduous journey, Cassini already has started sending stunning images back to Earth. Assuming the critical engine-burn works well on July 1, Cassini will go into orbit around Saturn and begin a four-year mission that promises to be a watershed in our knowledge of the entire saturnian system. Our own backyard telescopes also provide glorious views of the planet, ones that remain with first-time viewers their entire lives. So invite your neighbors over for a look and, while you're at it, suggest they turn off their outside lights for a better view.

Saturn now resides in Gemini the Twins, where on April 2 it reaches the northernmost declination in its 29.5-year-long orbit (22.8°). Although now several months past opposition, it still shines brightly at magnitude 0.1, making it easily the brightest object in the constellation. During April, you'll notice Saturn moving slowly away from Mu (μ) Geminorum, the 3rd-magnitude star in the northwestern corner of the constellation. The second-largest planet in our solar system, Saturn remains a superb object when seen through any telescope. The planet's disk currently measures 18" across while the rings span 41". By the end of April, Saturn sets around midnight.

CASSINI IMAGED SATURN on November 9, 2003, from a distance of 69.2 million miles. The spacecraft promises better shots in the next four years, but the view through even a small earth-bound telescope still is impressive. NASA/JPL/SPACE SCIENCE INSTITUTE

Saturn's moons also serve as nice targets for telescope owners, although they show up only as dots of light. Iapetus rates among the most intriguing, dimming and brightening regularly as it orbits Saturn. The moon fades throughout April as it moves from the western side of Saturn to the eastern side. By April 30, it glows at magnitude 11.9. Iapetus appears two-faced because one hemisphere is dark and the other bright. Perhaps Cassini will settle the question of why this is so.

Titan is the biggest and brightest of all Saturn's moons. This mysterious world supports a thick atmosphere that hides the surface from view. If everything goes well, the European Space Agency's Huygens probe (part of the Cassini mission) will parachute to Titan's surface in January 2005, forever changing our view of the moon. At magnitude 8.3, this world appears bright enough that you can follow it throughout its 16-day-orbit of Saturn. You'll find Titan due west of Saturn on April 6 and 22 and due east of the planet on April 14 and 30.



Saturn on April 8, 11:00 P.M. EDT

Several other moons can be observed around Saturn as well. Tethys, Dione, and Rhea each glow at 10th magnitude. Enceladus, at magnitude 11.7, is fainter, but 13th-magnitude Mimas represents an even bigger challenge.

If the activity of four planets in the western sky after sunset isn't enough, turn to the south after darkness falls to view **Jupiter**. Shining at magnitude –2.3 in Leo the Lion, it ranks second in brightness to Venus. Jupiter remains visible until well past midnight. The largest planet in the solar system provides a wealth of atmospheric detail for observers with telescopes. Its disk currently spans 42", so even small scopes will show features. Look for the two dark, parallel equatorial belts that cross the entire disk. Patient observers will see more detail as moments of still air reveal subtle shadings. (See "Jupiter at its best" on page 70 for more observing tips.)

Also look for the Great Red Spot, a faint, salmon-color feature on the southern border of the South Equatorial Belt. Don't be surprised if you can't recognize it, even if it's on the visible hemisphere — the feature has a much lower contrast than it did 20 years ago, when it appeared quite prominent.

The four Galilean satellites trek back and forth as they orbit Jupiter and prove to be easy targets through any telescope. Io, Europa, Ganymede, and Callisto pass in front of Jupiter once every orbit, casting their shadows onto the planet. It's easier to follow the moons' shadows than their disks as they traverse Jupiter.

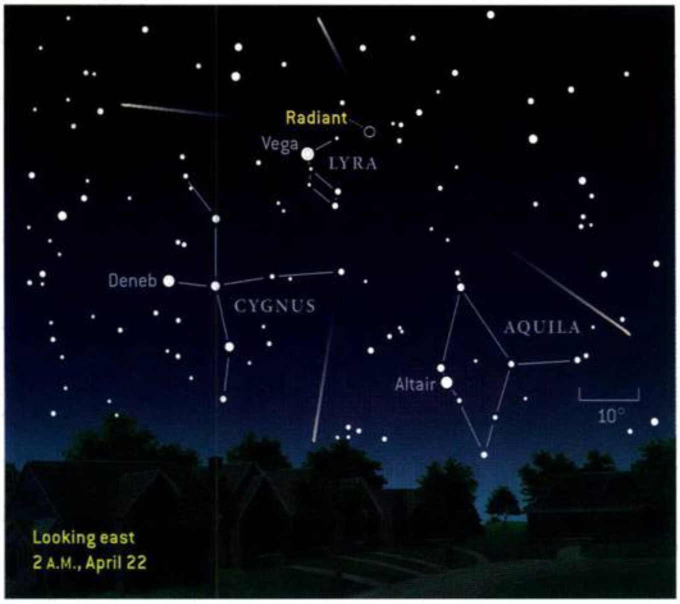
METEORS AND MOONS

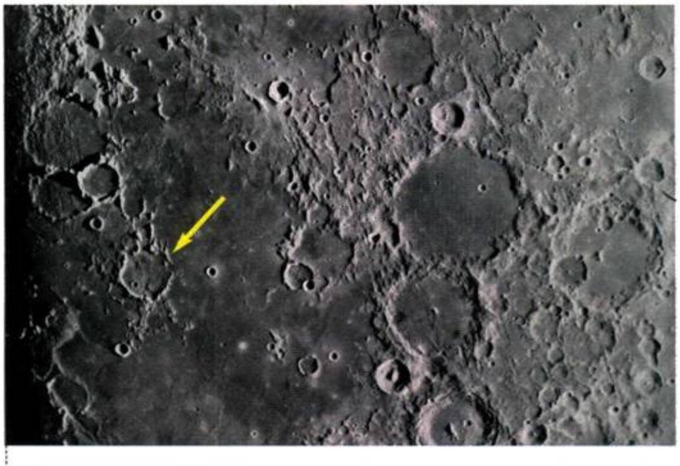
A good meteor shower peaks during the darkness of New Moon, while an intriguing lunar crater in the Fra Mauro region beckons observers with small telescopes.

The Lyre's shower

April's Lyrid meteor shower should peak around midnight on April 21/22. With New Moon on the 19th, the biggest source of natural light pollution will be off-stage all night. By midnight, the shower's radiant in Lyra already has climbed 30° above the northeastern horizon. Observations can start as early as 10:30 P.M. and run through dawn.

The expected hourly rate from a dark-sky site with Lyra overhead would be around 20 meteors. Fewer than that will be seen around midnight, but as the radiant rises during the morning hours, the rates may improve. Higher rates are rare, but not unheard of. In 1982, observers reported a brief period with four times the normal rate. This meteor stream clearly has one or two thicker strands, yet astronomers don't know enough to predict when or if Earth will encounter them this year.





THE CRATER GUERICKE (arrow) has a fairly flat floor marred by a small crater in the southwestern corner and also breaches through its northern and eastern walls. FROM *THE CONSOLIDATED LUNAR ATLAS* (LPL/UA)

Lunar crater Guericke

South and a bit east of Copernicus, embedded in the Fra Mauro region, lies the complex and ancient crater Guericke. This 36-mile-wide crater sits about 60 miles away from the larger Fra Mauro crater, near where the Apollo 14 astronauts landed. Guericke's floor appears rather flat, although small pits and some ridges dot the floor. These show up best at low-illumination angles, just after the Sun rises or before it sets over the region. This month, sunrise comes on the 28th and sunset on the 13th.

Breaches mar both the eastern and northern sides of Guericke's fractured wall. A huge pair of mountains flanks the wall's northern breach. Fresher, younger craters pock the region, including a fine example near the southwestern edge of Guericke's floor. A second, smaller crater deforms the southern wall. This whole region abounds with lava flows and craters of different ages.

/// APRIL CALLISTO EVENTS

	{ UT }	{ EDT }	{ Event }
5th	6h41m	2:41	IV.Oc.D.
	9h57m	5:57	IV.Oc.R.
	13h40m	9:40	IV.Ec.D.
	16h58m	12:58	IV.Ec.R.
13th	14h45m	10:45	IV.Tr.I.
	18h05m	14:05	IV.Tr.E.
	23h01m	19:01	IV.Sh.I.
		22:12	IV.Sh.E.*
14th	2h12m		IV.Sh.E.*
21st	21h56m	17:56	IV.Oc.D.
		21:25	IV.Oc.R.*
22nd	1h25m		IV.Oc.R.*
	7h45m	3:45	IV.Ec.D.
	10h54m	6:54	IV.Ec.R.
30th	6h31m	2:31	IV.Tr.I.
	10h00m	6:00	IV.Tr.E.
	17h03m	13:03	IV.Sh.I.
	20h05m	16:05	IV.Sh.E.

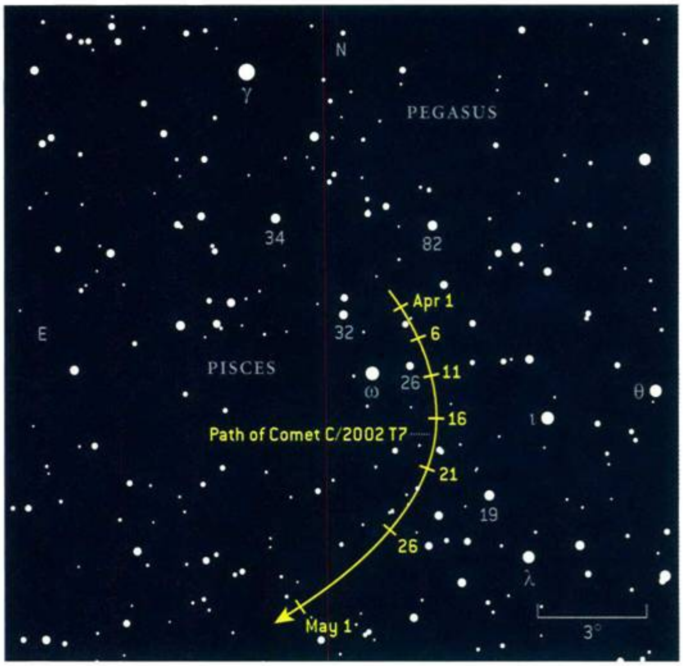
*Events that occur on either side of midnight are shown twice.

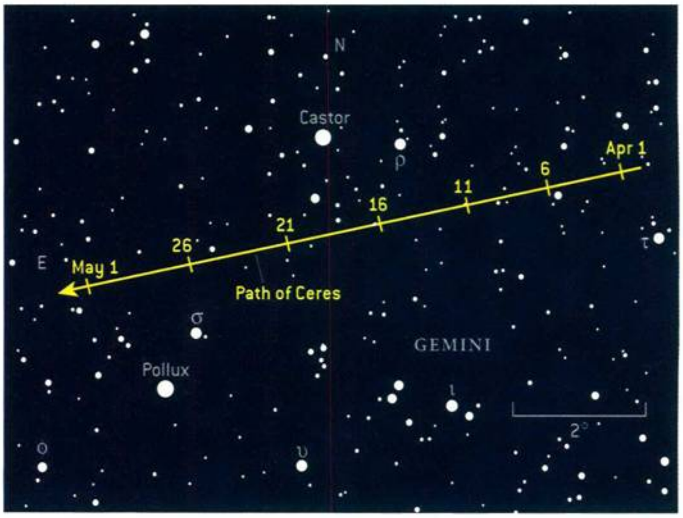
Jupiter's satellites

The current series of occultations, eclipses, and transits involving Callisto continue until September. The events listed above are given in both Universal Time and Eastern Daylight Time. Events that occur on either side of midnight are shown twice because the date changes for observers in Europe or North America. Tr = transit; I = ingress; E = egress; Oc = occultation; Sh = shadow transit; Ec = eclipse; D = disappearance; R= reappearance. The events are worth viewing due to their relative rarity. Not all events are visible from the United States.

COMETS AND ASTEROIDS

Comet C/2002 T7 (LINEAR) glows brightly low in the east before sunrise, but all eyes will swing to Comet C/2001 Q4 (NEAT) as it climbs into the evening sky in late April.





Rise and shine

After being a fixture in the evening sky for the past several months, Comet C/2002 T7 (LINEAR) rounds the Sun in April. We lose sight of it for a brief period before it reappears in the morning sky around midmonth. (In the few mornings before then, light scattered by the nearby Moon will wash out much of the tail.)

After New Moon on the 19th, get out under a dark sky with an unobstructed eastern horizon to view it. For many readers, the comet won't get much higher than about 7° elevation, about one field of view in standard binoculars. Find the lower left star in the Great Square of Pegasus (Gamma [γ] Pegasi) and from there, sweep to the right. Alternatively, you can start at the Square's lower right corner (Alpha [α] Peg) and sweep toward the horizon. Observers closer to the equator will get a better view because the comet appears somewhat higher in the sky there before dawn's light swallows it.

Astronomers forecast C/2002 T7 will brighten to about 2nd magnitude by month's end. That's if we're lucky. Many fresh comets fade by a couple magnitudes after their initial frost layer burns off, but if C/2002 T7 has big gas vents, we could be in for the show of the decade.

Southern Hemisphere observers already are enjoying a great view of the other comet of the decade, C/2001 Q4 (NEAT). During April, it cruises quickly from the Magellanic Clouds to a spot between Sirius and Canopus, all the while brightening to 2nd magnitude. That's great news if you live in the southern tier of states. On April 30, a fully grown comet complete with a long tail suddenly appears well to the lower left of Sirius. More northerly observers will have to wait another week or so for it to ascend into the sky.

Although binoculars show a comet with its tail to near perfection, don't forget to use a telescope to look for jets and multiple tails. Comets exhibit two types of tails: dust and gas. The dust tail appears yellow-white because it reflects sunlight; it also curves as each particle ejected from the comet follows its own orbital path. The gas tail glows blue as the ionized gas fluoresces. Unlike the dust tail, the gas tail points directly away from the Sun as the solar wind of high-speed electrons and protons pushes it straight back.

Ceres parts the twins

Earth continues to travel its faster, inner orbit and now is leaving the largest asteroid behind. Ceres fades slowly from magnitude 8.3 to 8.6 during April. This pushes binoculars a bit, but it remains within easy reach of even the smallest telescope. Fortunately, Ceres traverses the region between Castor and Pollux, so good guide stars abound. The asteroid should be easy to locate and follow from night to night using the chart above.

While you're in the vicinity, stop by Castor (the northerly twin and the one that lies closer to Capella) for a high-powered look at its binary nature. Just 4" separate the 2.0- and 2.9-magnitude luminaries, a comfortable split for a 50mm refractor at 100x. ■

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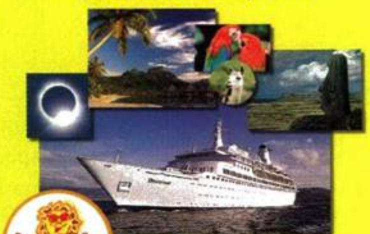

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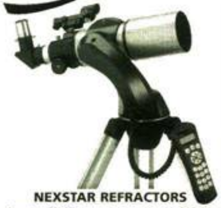

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ASK ASTRO

Seeing an eclipse from the Moon, alien astronomers finding Earth

ECLIPSE FROM THE MOON

While watching the November 2003 lunar eclipse with my daughter, she asked what it would look like from the Moon and if there have ever been any astronauts on the Moon during an eclipse.

— **ANTHONY CONRAD,** WOODSTOWN, NEW JERSEY

No astronauts walked the Moon during a lunar eclipse because such events always occur at Full Moon. The Apollo project avoided landings at Full Moon for safety reasons because the Sun would have been overhead. NASA required a low Sun-angle so astronauts could pick out lunar features more easily when highlighted by shadows.

Seeing a lunar eclipse from the Moon resembles seeing a total solar eclipse from Earth. An astronaut would watch the Sun slowly disappear behind Earth. The curve of the planet's edge would be apparent against the bright solar disk. From the Moon, however, Earth appears much larger than the Sun (not quite 2° across compared to the Sun's half degree), so Earth's center wouldn't have to pass directly across the Sun for an eclipse to occur.

Our planet could take a number of possible paths. During the recent total lunar eclipse on November 8, 2003, for example, the Moon did not pass through the center of Earth's shadow but skirted one edge. Viewed from the Moon, the Sun would have been covered primarily by one side of Earth. Compared to Earth's diameter, the thickness of the main part of our atmosphere is less than one percent, so as Earth began to cover the Sun, our atmosphere would not dim the Sun's light or redden it to any degree. It's probable, however, that during totality, a thin part of the atmosphere on one side of Earth would be a lot brighter than the other.

Now for the cool part. At the moment of totality, an astronaut would see the lunar surface transform from a brilliant whitish-brown to a faint coppery-orange.

COPPERY LIGHT bathes the Moon during a total lunar eclipse. What would astronauts standing on the Moon see if they looked back at Earth — and did any astronauts ever see such a thing? GREGORY TERRANCE

Actually, the color would depend on how central the eclipse was and how much particulate matter (dust, ash, etc.) was in Earth's atmosphere. The contrast between pre-eclipse brightness and totality would be so extreme that the landscape probably would disappear until the astronaut's eyes adjusted to the much lower light level. Looking toward Earth, the astronaut would see a thin ring of reddish light surrounded by stars.

How long the Sun would be covered by Earth's disk depends on the astronaut's location on the Moon. At the end of totality, the astronaut would see the Moon's surface once again flooded with sunlight. The effect would be like standing in a dark closet for several minutes and then turning on the light.

I hope this helps. Remember, I'm trying to explain something nobody has ever seen! — **MICHAEL E. BAKICH,** ASSOCIATE EDITOR

FINDING EARTH

If beings from a distant solar system looked for planets around the Sun using the radial-velocity method, what would the results reveal? Does our Sun move around in space enough to tell them anything?

— **BILL SCHUSTER,** REDFORD, MICHIGAN

So far, we humans have discovered 120 planets orbiting nearby stars. Most of these planets have masses similar to those of our Jupiter and Saturn, but they orbit closer. They all were discovered by detecting the wobble of the host star. This wobble shows up as a slow periodic change in the star's radial velocity — its speed toward or away from us. This can be measured accurately by the Doppler shift of the starlight's spectrum.

If an alien civilization had similar technology, could they detect our solar system? With patience, the answer is definitely yes. The Sun makes a little curlicue pattern in space because the nine planets yank on it gravitationally. The biggest bully is Jupiter. During its 11.86-year orbit, Jupiter pulls the Sun around in a circle with a speed of 41 feet (12.5 meters) per second — just a little faster than a person can sprint.

A distant observer, dozens of light-years away, could point a telescope at the Sun and try to detect its motion. This would change alternately toward and away during a 12-year period. The alien observer would need a big telescope equipped with a first-rate spectrometer designed to spread the white light of the Sun into its composite wavelengths of light, from blue to red. Due to the Doppler effect, solar spectral lines would change wavelength as

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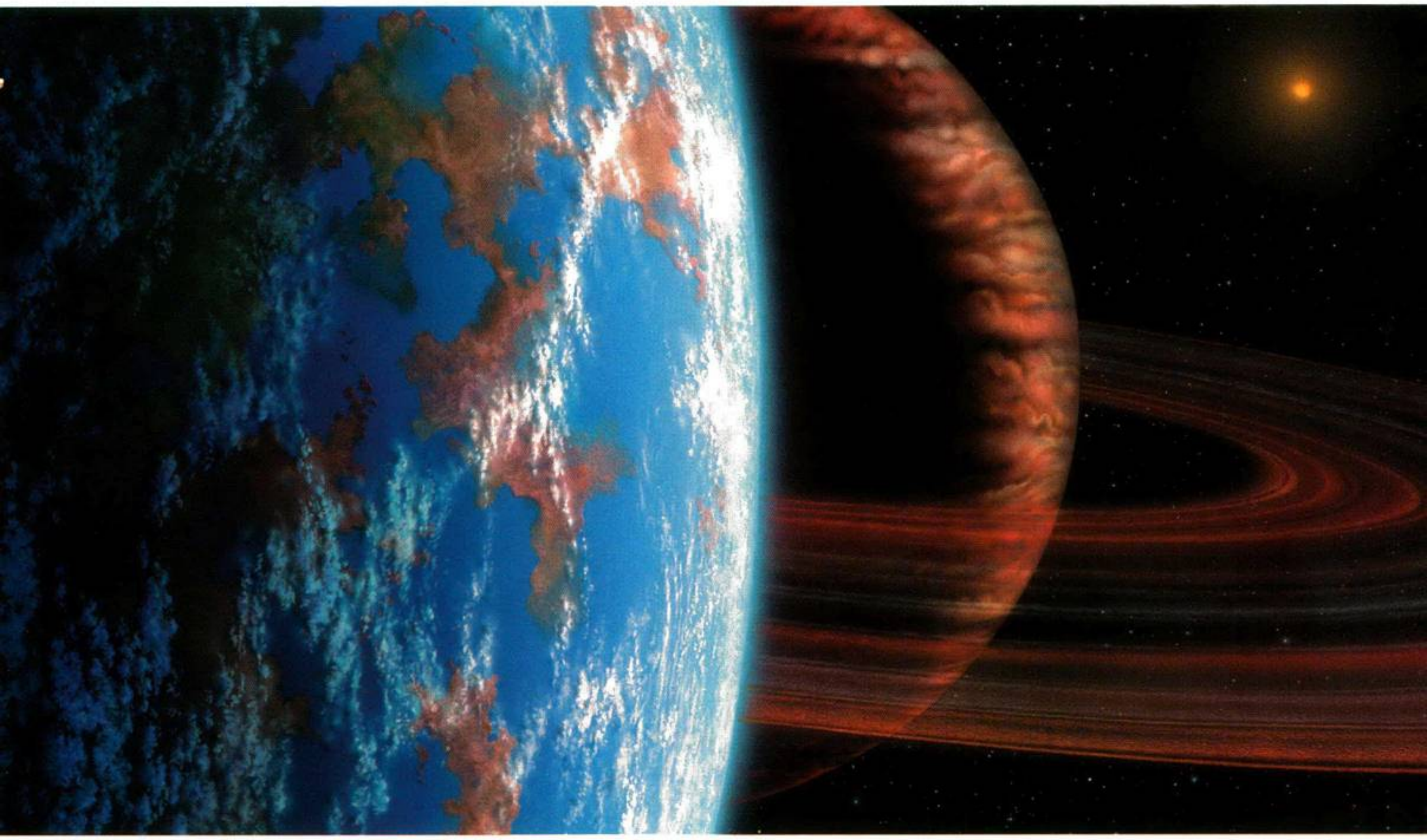

WE HAVE FOUND EXTRASOLAR planetary systems by measuring the wobble planets create as they waltz with their stars. But could alien astronomers detect planets in our solar system using these tools? ARTWORK BY LYNETTE COOK

the Sun alternately approached and receded from the alien observer.

The solar wavelengths would change by only 3 parts in 100 million. This is the same amount by which a wooden ruler changes length due to gravity when you stand it on end. Put another way, the Doppler effect of the Sun moving at 41 feet per second is extraordinarily tiny. Nonetheless, with modern spectrometers and telescopes, humans have learned how to measure such tiny speeds using the Doppler effect. In fact, we can measure speeds as low as 10 feet (3 meters) per second — easy bicycle-cruising speed.

So aliens certainly could detect Jupiter, but only if they carry out telescopic observations for at least 12 years to detect the full "wobble" of the Sun caused by Jupiter. Saturn imparts a solar wobble of 9 feet (2.7 meters) per second, making it just barely detectable — but only if the aliens can wait for 30 years while Saturn yanks the Sun around. The aliens would have to subtract the wobble caused by Jupiter to detect the residual wobble caused by Saturn. The two wobbles would be distinct because they have different periods, 12 and 30 years, superimposed on each other. Like seeing ripples riding on top of waves in the ocean, aliens could sense the two biggest planets in our solar system easily.

Armed with our current Doppler technology, alien observers could not detect Earth or the other smaller planets orbiting the Sun. Earth causes the Sun to wobble by only 4 inches (10 centimeters) per second, well below our Doppler sensitivity. NASA currently is working on three space-borne telescopes designed to detect Earth-like planets. Kepler, slated for launch in 2007, will detect the dimming of a star as an exo-Earth transits the star's face. The Space Interferometry Mission will directly discern the wobble of a star relative to its neighboring stars; the tiny wobble caused by small, terrestrial-size planets will be detectable. Finally, the Terrestrial Planet Finder mission (from the United States) and Darwin (from the European Space Agency) will take the first pictures of Earth-size planets by blocking the glare from the host star that would otherwise overwhelm the planet.

This means aliens that are just 25 years more advanced than us would have such space-borne telescopes at their disposal already and would be able to study our Earth directly. Within 100 years, as the alien astronomers increased magnification, they would see how well humans resolve international differences and distribute our resources. We might wonder what first impression we are making to our galactic neighbors. — **GEOFF MARCY,** UNIVERSITY OF CALIFORNIA, BERKELEY

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PLANETARY OBSERVING

Get the lowdown on Jupiter's atmosphere just in time for the giant planet's prime-time show. /// TEXT AND IMAGES BY DAMIAN PEACH

Jupiter at its best

It's Jupiter time again. The giant planet is now well placed for observing, and telescopes of all sizes are pointing its way. Jupiter is a great object for beginning observers because of its brightness, relatively large size, and the number of features within its clouds that can be seen. The descriptions used by astronomers to describe jovian activity can be confusing, and many observers get their belts and bands mixed up. Jupiter's atmosphere presents a structure defined by a multitude of jet streams encircling the globe. What follows is needed by every observer of the king of planets: a complete guide to the jovian atmosphere containing the descriptions and nomenclature as defined by the British Astronomical Association (BAA) Jupiter section. Amateur astronomers who have seen more than a few apparitions of Jupiter are aware of the high level of activity on the planet and have become familiar with the terminology, lengthy as it is. If Jupiter observing is new to you, don't be discouraged by all the terms. If you learn what a particular belt (darker region), zone (lighter region), or smaller feature is called when it catches your eye, you'll spend some time observing it. And then, in no time, you'll be an expert on Jupiter's features and names. Good luck!

Damian Peach *is assistant director of the BAA Jupiter section, as well as the ALPO Jupiter section.*

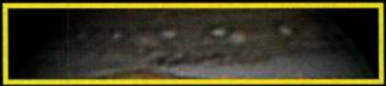
[SPR]

[SOUTH POLAR REGION] Let's start our tour of Jupiter at the bottom of the planet. Remember, however, that in a normal telescope the image is inverted, so as you look through your eyepiece, the bottom of the image becomes the top. The South Polar Region is a dark area that covers Jupiter's south pole. Occasionally, high-resolution CCD images show small dark and bright spots, but for the most part, the area is pretty featureless visually.

[S3TB & S3TZ]

[SOUTH SOUTH SOUTH TEMPERATE BELT AND ZONE] The areas where small storms become noticeable are the South South South Temperate Belt and South South South Temperate Zone, which lie adjacent to the pole. The storms usually take the form of small, bright regions of anti-cyclonic (clockwise) rotation, and some become quite prominent. The S3TB usually isn't definable as a separate belt, although the S3TZ has been well defined in recent years.

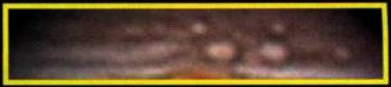
[SSTB & SSTZ]



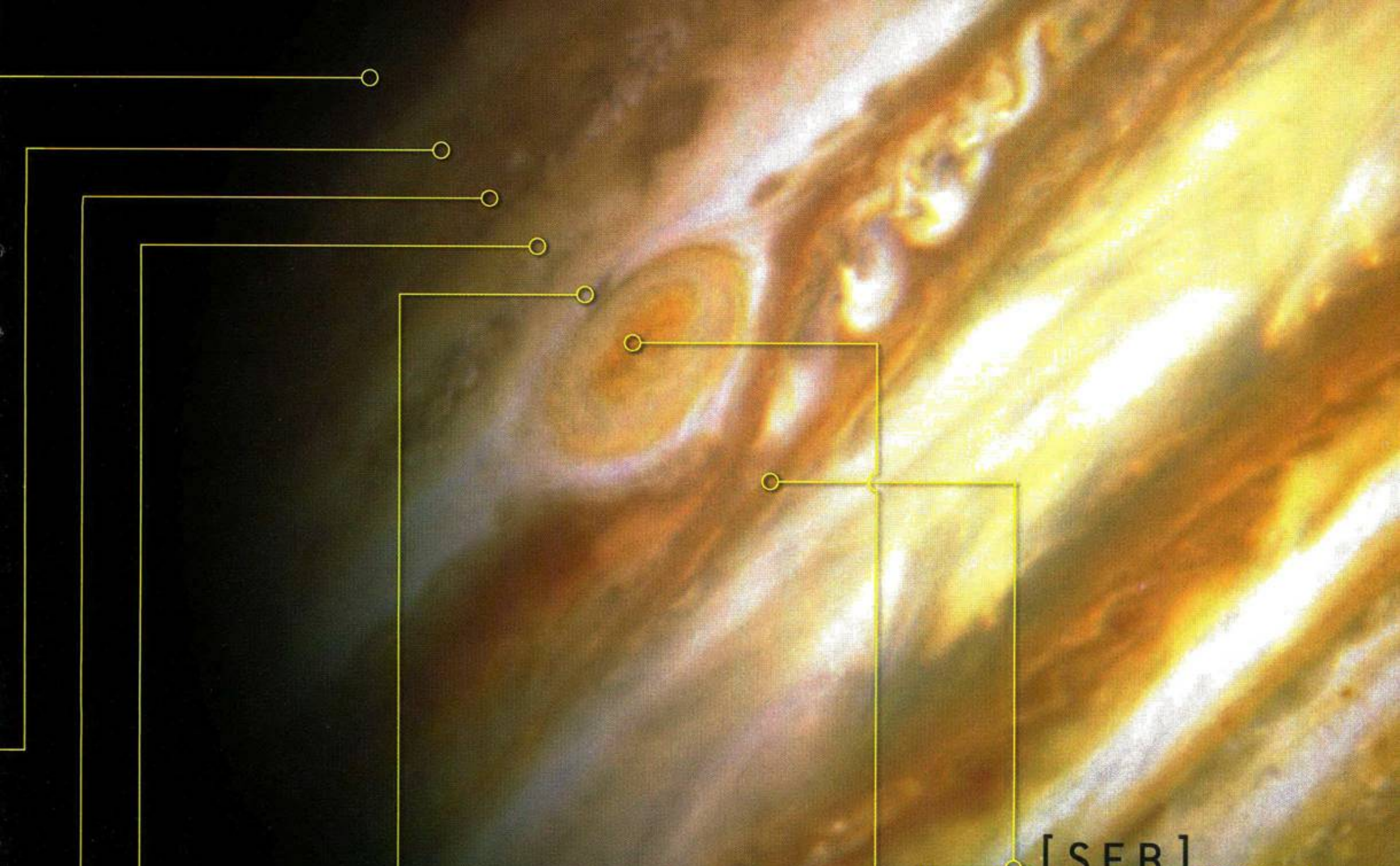
[SOUTH SOUTH TEMPERATE BELT AND ZONE] The South South Temperate Belt often presents a great amount of detail to observers, mainly bright, anti-cyclonic storms that propagate within the belt. Usually between five and eight storms are present, visible through 5-inch or larger telescopes. The storms span between one and two thousand miles across and can last several years. Their brightness results from high-altitude ammonia ice clouds circulating in the top of Jupiter's atmosphere.

Other interesting details are visible within the SSTB such as irregular cyclonic circulations and occasional dark spots. The South South Temperate Zone, on the other hand, usually appears bland, with details such as small dark spots occurring only rarely.

[STB & STZ]



[SOUTH TEMPERATE BELT AND ZONE] The South Temperate Belt normally consists of dark streaks scattered around the planet, but in recent years the belt has all but disappeared. This doesn't make it less interesting, however, because the STB historically has been an area of notable activity. For more than sixty years it was the site of what observers dubbed the "three great white ovals." The three ovals were designated BC, DE, and FA, and they persisted until they formed a close grouping during the 1997 apparition. BC and DE collided and merged into a single oval during 1998 while Jupiter was behind the Sun (and invisible from Earth). The new, larger feature, named BE, remained prominent throughout the 1999–2000 apparition. After BE and FA passed the Great Red Spot in late 1999, they collided in March 2000. This time, however, amateur astronomers were able to follow the collision of the two huge anti-cyclones, which formed one storm that still persists today — the oval known as BA.



[STrZ]

[SOUTH TROPICAL ZONE] The South Tropical Zone is the narrow, usually bright zone between the STB and the south edge of the SEB. It's best known as the home of the Great Red Spot. Other features occasionally appear in the STrZ, such as small anti-cyclonic ovals. Several such storms have been observed during the last several years, and most of them seem to occur in the area preceding the Great Red Spot. Indeed, some actually have been drawn into the Great Red Spot and destroyed.

[GRS & RSH]

[THE GREAT RED SPOT AND RED SPOT HOLLOW] The most famous and by far the largest storm in the solar system, the Great Red Spot has captivated astronomers since the first critical observations of it were made in 1821. Since then, the storm has shown variations in color, size, and drift rate (with respect to its position in the South Tropical Zone). The storm is slowly shrinking, and it is now one-third shorter in length than it was in the 1890s. The region with the same general shape surrounding the GRS is designated the Red Spot Hollow. The Hollow is similar to the Great Red Spot, but it lacks the high level of cloud circulation and, of course, the color.

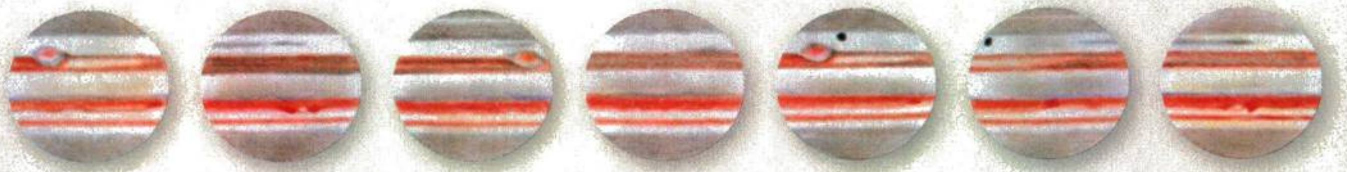
The GRS shows almost yearly changes in color. In the past, the color has varied from brick red during the 1960s to pale pink in the 1990s. Since 2000, the color has remained light orange, although the GRS darkened slightly between 2002 and 2003.

[SEB]

[SOUTH EQUATORIAL BELT] The South Equatorial Belt is Jupiter's most active belt, the scene of periodic disturbances. Two dark, easily confused features are found at the southern end of the SEB. The more noticeable feature is the SEB south component. The second feature is a jet stream that marks the southern edge of the SEB. It often shows heightened activity when small spots develop and move quickly along the belt in a direction opposite Jupiter's rotation.

The most spectacular of all jovian atmospheric events is an SEB revival, which — as you might guess — is always preceded by a fading of the SEB. Over the course of several months, the SEB will fade away. During these times (known to last for more than a year and a half), the Great Red Spot darkens. Then, suddenly and without warning, a brilliant white spot/dark spot pair will erupt on the SEB, near and just preceding the GRS. Dark material violently erupts from this "source," and as it spreads, the whole SEB eventually is restored. As the belt darkens, the GRS fades in color.

In the area of the SEB 50° following the GRS, bright spots known as the post-GRS turbulent region often appear. The spots slowly move in the direction of Jupiter's rotation toward the GRS. New spots periodically erupt in this region, and the level of activity can be well above what's normally observed.



April 19, 2002 20h00m UT

April 20, 2002 19h48m UT

April 21, 2002 20h37m UT

April 23, 2002 20h25m UT

April 24, 2002 19h46m UT

April 24, 2002 20h25m UT

April 25, 2002 20h22m UT

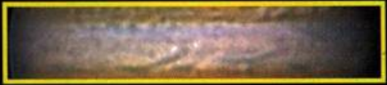
This impressive series of sketches was made by Damian Peach using an 11-inch Celestron Schmidt-Cassegrain telescope and magnification of 334x from Ten-Bel, Tenerife, Canary Islands. Note the detail visible, especially around the areas of the two equatorial belts, the Great Red Spot, and the polar regions.

Sketching is an often-neglected pastime of amateur astronomers. If you've yet to try it, I want to state two things up front. First, you do not have to be an artist. Second, sketching Jupiter will make you a better observer.

With regard to the first point, be happy with what you sketch and know — with absolute certainty — that you will get better. Here's something I learned early in my sketching career: For the most part, you'll be sketching circular objects, so don't make the circles too large. The first few times I sketched objects at the telescope, I used circles that barely fit on a full sheet of paper. The sketches seemed to take forever to complete!

As to the second point, when you start sketching Jupiter you will, by necessity, spend more time looking at it and memorizing small areas of detail before transferring what you see to paper. The more this becomes part of your observing routine, the better observer you will be. For more tips about sketching Jupiter, visit www.astronomy.com/toc. — *Michael E. Bakich*

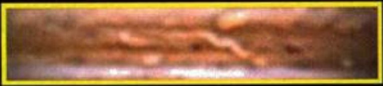
[EZ]



[THE EQUATORIAL ZONE]
Jupiter's Equatorial Zone is well known among observers as the most dynamic and rapidly changing region on the planet. Although the Equatorial Zone is generally lightly colored, dark material usually is present across it, and in some years spectacular arrays of festoons (see North Equatorial Belt) persist, emanating from the southern edge of the NEB.

Large, dark ovals have been seen occasionally in the EZ. This zone appears quite different now than it did two decades ago, when it appeared brownish like the NEB.

[NEB]



[NORTH EQUATORIAL BELT] The darkest and most prominent belt on Jupiter is the North Equatorial Belt, which is easily seen even through a 2-inch telescope. It shows great activity, with many interesting features.

Festoons are bluish, roughly triangular features that originate in the southern edge of the NEB. They are clouds that appear projected over the EZ and can be seen almost all the time.

NEB expansion events refer to periods when the north edge of the NEB expands northward, giving the belt a much thicker appearance. These expansion events usually occur every three years and persist for an entire apparition.

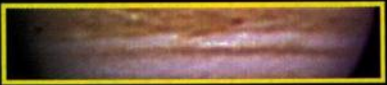
Bright, white plumes sometimes appear in the southern edge of the NEB and northern edge of the EZ and usually are situated alongside NEB festoons. In smaller telescopes, these plumes sometimes look like huge ovals.

Mid-NEB rifts are features that persist in the middle of the belt and erupt usually as brilliant white clouds. The gradual drop in wind speed from the Equatorial Zone to the NEB shears these brilliant spots into turbulent, elongated rifts that can persist for weeks.

NEB barges are dark, cyclonic circulations on the northern edge of the NEB. Barges usually appear round and occasionally elongated.

NEB bays (white ovals) are bright anticyclonic storms that persist along the NEB's northern edge. Some can be prominent.

[NTB & NTZ]

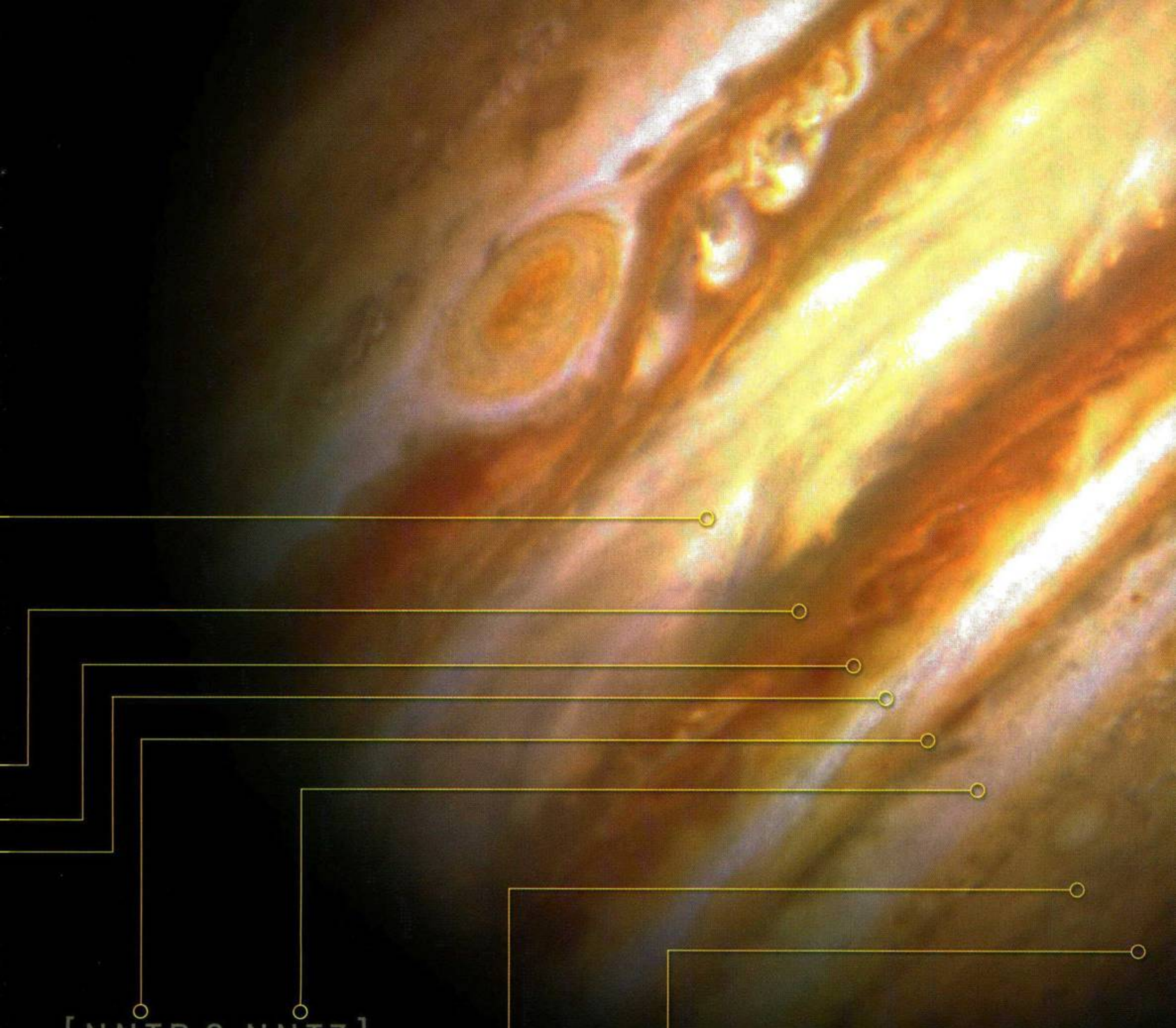


[NORTH TEMPERATE BELT AND ZONE] To observers, the NTB is usually third in prominence, inferior only to the North Equatorial Belt and South Equatorial Belt. Several interesting patterns of activity exist within this belt.

The NTB south jet stream (NTBs) is the fastest moving jet stream in Jupiter's atmosphere. Four different jet stream speeds have been observed during the last 150 years. Spots within the jet stream appear as dark "bumps" on the NTBs, and movement relative to other features can be noted easily after only one day.

Periodically, the NTB gradually fades away, leaving perhaps a few dark segments behind. NTB fading usually takes a few months, but unlike the South Equatorial Belt, the North Equatorial Belt does not revive in an "explosive" manner — it gradually returns to prominence.

IO: PIRL/UNIVERSITY OF ARIZONA



NASA AND THE HUBBLE HERITAGE TEAM (STScI/AURA)

[NNTB & NNTZ]

[NORTH NORTH TEMPERATE BELT AND ZONE] This belt often appears as detached sections of dark material rather than as a continuous belt. In recent years, the North North Temperate Belt has been rather faded, although in 1997 it appeared more prominently than it does now.

One example of NNTB activity is the NNTB south jet stream (NNTBs). This jet stream shows periodic outbreaks of dark spots, often with a slightly bluish tint to them, which move rapidly in the direction of Jupiter's rotation.

As with the South South Temperate Belt, the North North Temperate Belt and North North Temperate Zone also frequently display anti-cyclonic white ovals, although in general they are smaller and less numerous than their southern counterparts.

[N3TB & NPR]

[NORTH NORTH NORTH TEMPERATE BELT AND NORTH POLAR REGION] These features are found in areas north of the North North Temperate Zone. Activity here generally consists of a chaotic mix of dark spots and streaks and also anti-cyclonic white ovals. In addition to the North North North Temperate Belt, N4TB and N5TB occasionally have been reported, but observations of these belts have been sporadic.

So there you have it — lots and lots of names for features on a distant world. To get the most from this list, don't try to tackle it in a single observing session. Rather, use it as a long-term checklist. One night, for example, pay particular attention to the South Equatorial Belt. On another night, observe Jupiter's polar regions. Use as many eyepieces and filters as you have and be patient. Before long, you'll be familiar with all the jovian features — and a better observer to boot! A

ASTROPHOTOGRAPHY

Even the best astrophotographers make mistakes. Learn from an expert how to avoid some common miscues. /// TEXT AND PHOTOGRAPHS BY DAVID HEALY

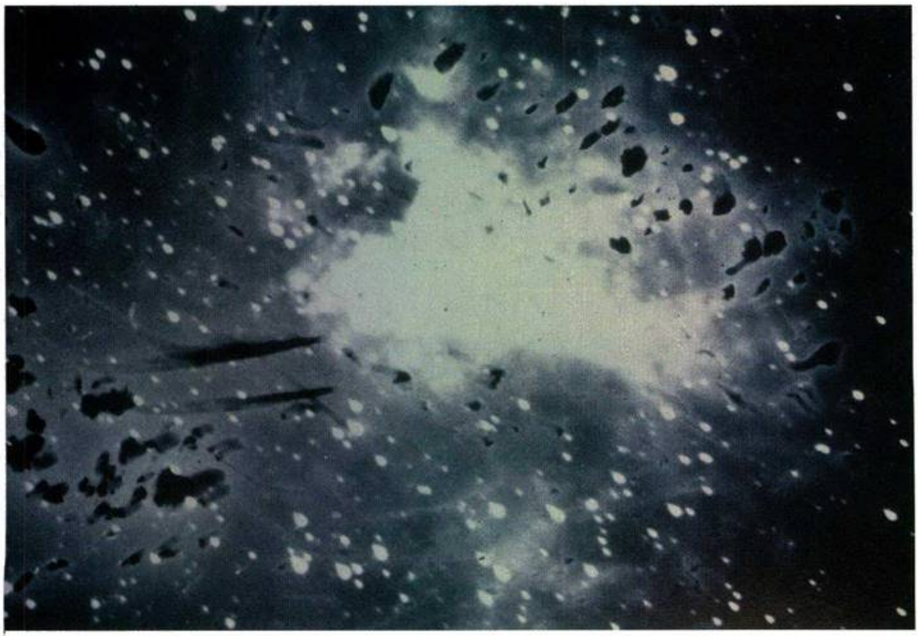
When astrophotos go bad

Photographers who are competent enough in the daytime seem to lose about 50 IQ points when they take their cameras outdoors at night and try to take astronomical images. We waste film by the yard, produce images suitable only for the trash bin, and in the meantime, generate high levels of stomach acid and blood pressure.

Why we astrophotographers produce so much garbage remains something of a mystery. Certainly Murphy's Law ("if anything can go wrong, it will") plays a major part in our film-wasting blunders. But many sky-shooting techniques are not intuitive to the snapshot taker, and hey, it's dark out there! Let's face it: The objects we're trying to photograph often are nearly invisible, small in angular size, move with Earth's rotation, and certainly won't respond to a flash unit. So they generally require long time-exposures to record properly, which in turn requires either a fixed tripod or an electrically driven mounting that tracks the sky. A fertile ground indeed for Mr. Murphy.

A physical or mental mistake?

Having taken hundreds of bad astronomical photographs (and bad CCD images, for that matter) over the years, I have found that photos deserving of the dumpster fall into two broad categories: those ruined by physical mishaps and those ruined by the photographer's own mental slippage.



THE OMEGA NEBULA (M17) EXPLODES! Actually, the film negative's emulsion was dissolved by thumbprints wet with suntan lotion.

Physical goofs arise when either you or external factors prevent your equipment from working as intended. Examples of physical mistakes include tripping over your tripod when the camera shutter is open for a time exposure, letting dew form on your lens, or losing your cable release in the bushes at 2 A.M. Mental mistakes might include exposing a photo of a galaxy for 30 seconds when at least 30 minutes are required to record it properly, or trying to photograph details on the Moon with a standard 50mm camera lens — a format that would require 80 Full Moons side-by-side to fill the frame.

Fixed-camera goofs

Astrophotography with the camera supported by a fixed tripod (example: a photo of star trails) probably has fewer pitfalls than other, more challenging methods. However, there's still much that can (and will) go wrong. Wind (or the photographer) disturbing the tripod or camera during the exposure will ruin a photo (unless, perhaps, you're into abstract art). A camera weighed down with a large telephoto lens tends to slip on the tripod's head, especially if the camera is mounted vertically. Forgetting to put your cable release (and you must use a cable release for time exposures) into the locked-open position or forgetting to set the camera's shutter to "Time" or "B," both easy to do in the dark, will result in a time exposure taken with the shutter closed. And there's always that old standby: leaving the lens cap on. Humid nights may cause the camera's lens to dew up, resulting in blurred and low-contrast photos. Glare from surrounding streetlights or from your neighbor's 2,500-watt porch light may, if it falls on your lens, result in unwanted flare or ghost images in your pictures.

Fixed-camera remedies

The cure for disturbing the tripod during the exposure is twofold: Don't kick or fall over the tripod during a time exposure; and more helpfully, use a tripod that seems much too large, much too heavy, and generally over-engineered for the job you're asking it to do. The inertial mass of a large tripod will steady the camera, making it more resistant to wind and accidental bumps. You might even consider weighing the tripod down with a cinder block suspended by rope from either the central rod or the tripod head.

Most of the other physical mistakes mentioned above can be avoided by developing an unvarying routine of setting up and taking a photo in the dark. Check all your settings and positions twice before opening the shutter. And go through your routine slowly — remember, with your IQ reduced by 50 points, mistakes are easy, especially if you try to rush the process.

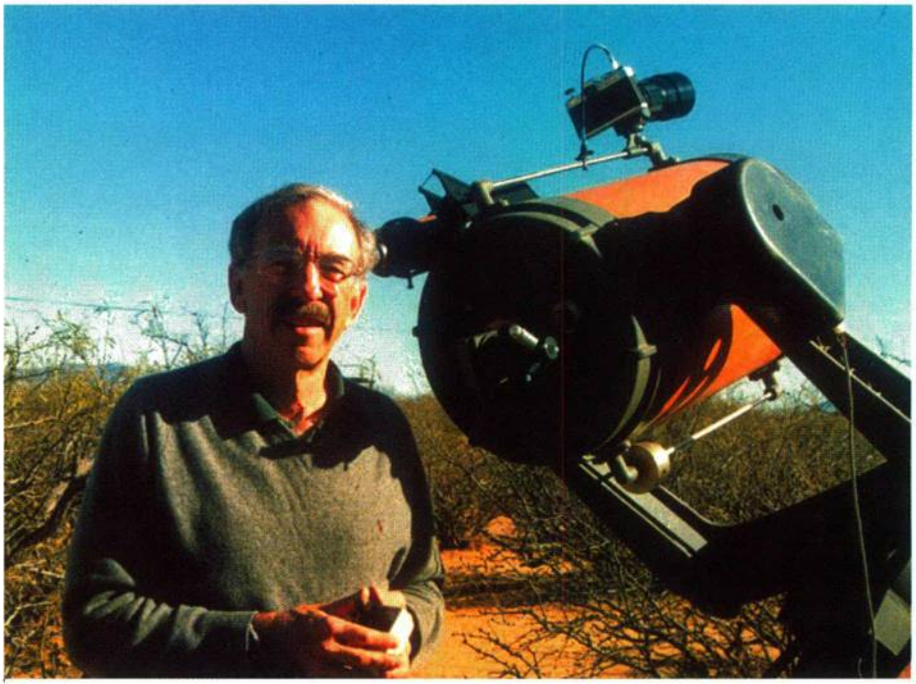
Always use a lens hood or a dew cap on your lens during a fixed-camera exposure or when you are piggybacking your camera on a telescope. A lens hood will not only prevent stray light from hitting your lens, it also will provide some protection against dew. If the dew is heavy, consider gently warming your camera lens with a hair dryer. This can even be done during a time exposure if the dryer is held to the side, out of the field of view of the camera. When it's so humid outside that everything is dripping, go inside and read *Astronomy* or use the time to plan a move to a drier climate.

Mental goofs and remedies

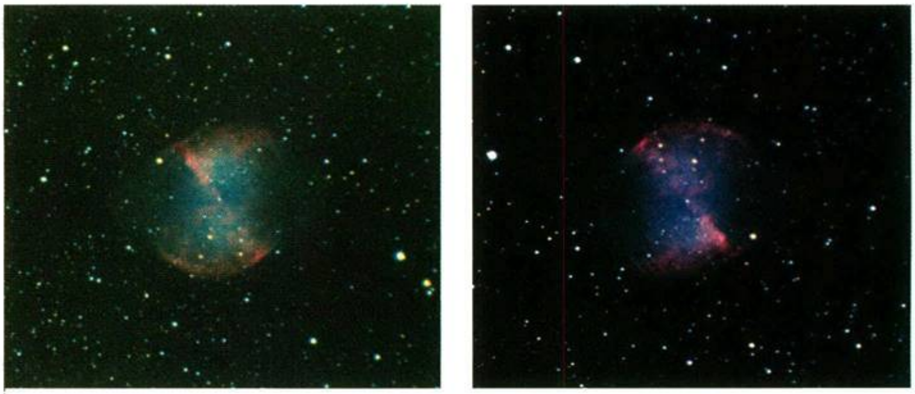
The most common mental mistakes in film photography involve choosing the wrong film, exposure time, lens opening, or image scale. It's not intuitive to beginning astrophotographers how faint most of their photo targets are, and they often neglect to use strategies that will get as much light as possible onto a sensitive film emulsion. The result: blank or nearly blank pictures — and the adoption of a new hobby by the photographer.

How much light?

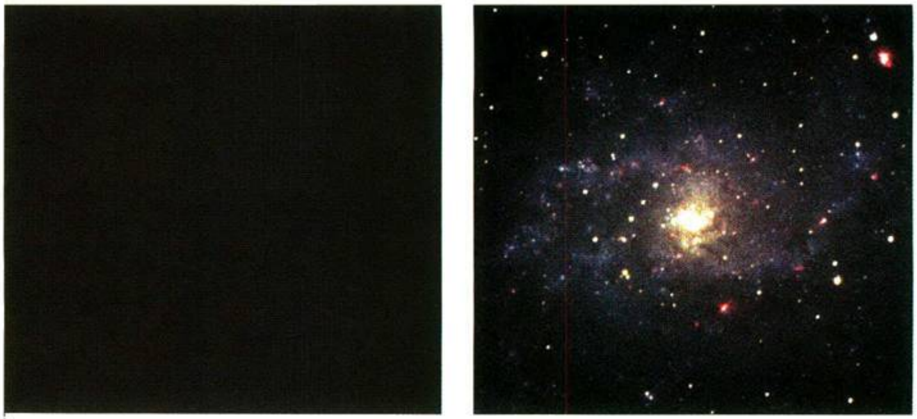
This is not the place for a dissertation on film selection, but I would suggest using, at least for starters, Kodak or Fuji color slide films with speeds of ISO 400 or higher. A notable exception to the "your targets



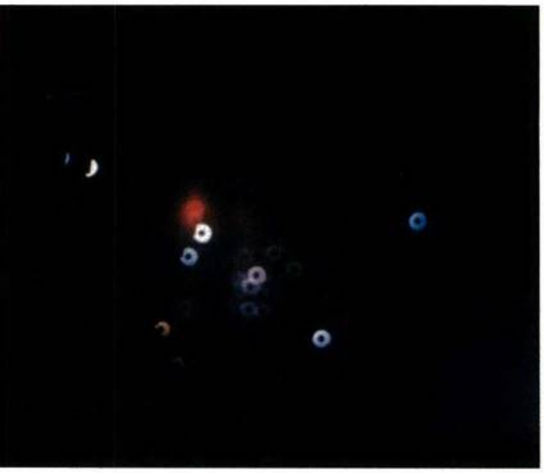
DAVID HEALY poses with a 35mm camera piggybacked to a 14-inch Celestron Schmidt-Cassegrain telescope. David has, in his own words, "committed hundreds of bad astrophoto mistakes." On the other hand, he's produced thousands of superb images, discovered more than seventy-five asteroids, and was an original contributor to *Burnham's Celestial Handbook*.



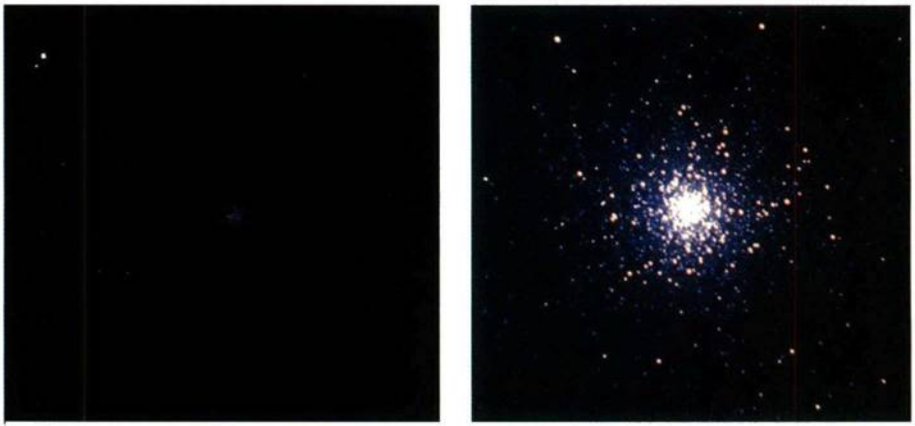
THE DUMBBELL NEBULA (M27) hovers in a green sky (left), courtesy of light pollution near the site where the image was created. The image also is reversed. M27 (right) looks much better in a dark sky, courtesy of home image-processing. This image is oriented properly.



THE PINWHEEL GALAXY (M33) (left) was a guided, 75-minute exposure with the shutter speed dial of the author's 35mm camera set at $1/125$ second. A much better image of M33 is shown at right. In this case, the camera was guided for 135 minutes with the shutter speed dial set at "B."



THE LAGOON NEBULA (M8) is shown here with "SCT Donuts," i.e., poorly focused star images with a 14-inch Schmidt-Cassegrain telescope. (Please note that the author does not hold the telescope responsible for this goof.) No "SCT Donuts" are evident in the image at right, but slight guiding errors are apparent.



THE GREAT GLOBULAR CLUSTER M13 in Hercules is shown here with (left) and without (right) "foot binaries," i.e., the author kicked the tripod during the left exposure.

are very dim" rule is the Full Moon. Because it is a front-lighted object about the same distance from the Sun as your backyard, use the same f/stop and shutter speed on your camera for the Full Moon as you would for an ordinary snapshot. The combination of your camera's f/stop and shutter speed, as well as the film speed you select, will make the proper exposure times for other astronomical targets vary considerably.

Frankly, the ideal way to determine the best film speed, exposure time, and lens opening for your picture is a trial-and-error method with the fancy name of "bracketing." Here's an example: If your best guess is that your shot of a crescent Moon with a telephoto lens would require a one-second exposure, take twelve exposures ranging from 1/60 second to 30 seconds. You also can vary your lens opening between f/4 and f/8 for each of the shutter speeds above. What result should you expect? You may get as many as four or five good shots from a 36-exposure roll of film. (That is, if you remember not to kick the tripod during the exposure.)

The best way to avoid future mistakes is to keep good records and plan your next photo session. Even if a bracketing exercise produces nothing useful on an entire roll of film, there probably will be at least something on your slides to indicate in which direction the proper exposure time and/or lens opening lies.

Image scale

Mars, at its nearest point to Earth, is less than 1/120° in diameter. It would take about 25,000 Marses — placed side by side — to stretch across our sky from one horizon to the other. It would take about 360 Full Moons side by side to do the same. Yet depending on whether we choose a fisheye lens or a 12-inch telescope, we can take pictures of either the entire sky or a single planet. Beginning astrophotographers discover — to their irritation — that the Moon looks like a dot on a photo taken with a normal 50mm camera lens and that the Big Dipper won't fit in the field of view of their 90mm lens. Disappointment with the tiny apparent size of an astrophotographic target is one of photographers' main gripes. For most celestial targets, a long focal-length lens or a telescope will prove desirable if not necessary.

Light pollution

"Photo rage" is a syndrome that can develop frequently if one's portrait of the constellation Orion comes back from the drug store with a bright green sky and the constellation's stars almost invisible through the smog. Don't blame the drug store photo guy — blame the drug store parking lot — your green sky is due to light pollution, particularly that coming from mercury-vapor light fixtures. In general,

David Healy *has been an avid astrophotographer for decades. His new passion, asteroid astrometry, has netted him more than 75 discoveries.*

the bright, polluted skies of urban and many suburban locations prevent photography of most deep-sky objects. The photographer affected by light pollution has three choices: limit oneself to imaging the Moon or planets; drive or move to a dark-sky area for photography; or invest in a CCD camera, which, with the addition of image-processing software, often can overcome a significant level of light pollution.

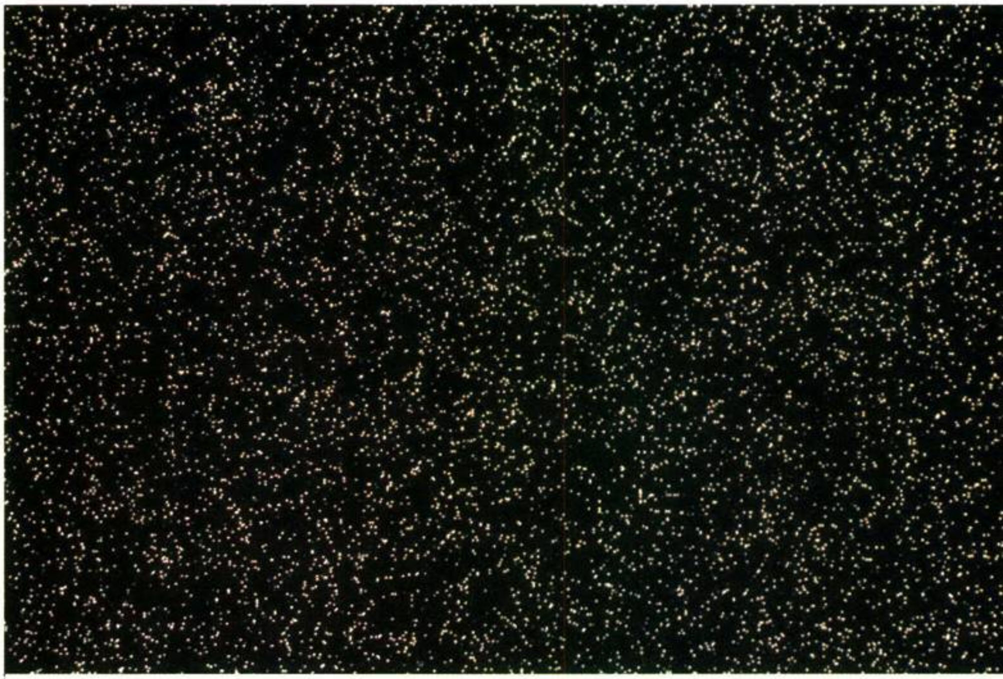
Advanced mistakes

Photography through a telescope with either a film or CCD camera opens the way to more sophisticated mistakes, in addition to being subject to the blunders already described. For example, unless your telescope mounting is superb and polar aligned accurately, you will need to guide the telescope (using a crosshair eyepiece or an auto-guider) for most through-the-telescope time exposures longer than 15 seconds. Guiding presents a cornucopia of opportunities for physical and mental goofs. Something as simple as temporarily forgetting which button on your keypad moves your guide star in which direction will create trailed images, spoiling your photo. I have produced numerous examples of "foot binaries" — "doubled" stars resulting from kicking the tripod during a time exposure. Moreover, I claim to have invented the "nose spiral," the path a bright star traces on your image after you have hit the guiding eyepiece with your nose.

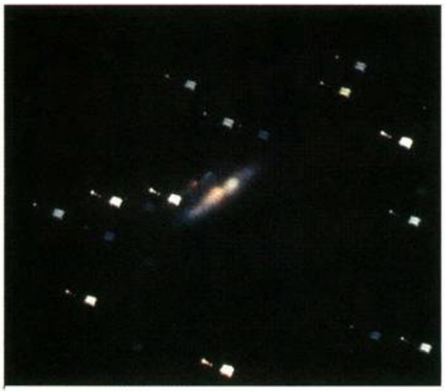
To track the sky properly, the Right Ascension, or R.A., axis of an equatorially mounted telescope needs to be aligned closely to the North Celestial Pole, a point only 0.7° away from Polaris, the North Star. Southern Hemisphere observers are less fortunate as far as alignment is concerned because no bright star lies near the South Celestial Pole. North of the equator, polar alignment starts by pointing the scope's R.A. axis in the direction of Polaris and then refining the alignment with a series of complicated procedures.

CCD imaging: bad news and good

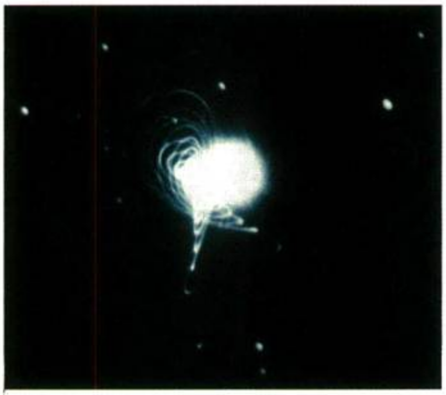
The transition from imaging with film to digital imaging with a CCD (charge-coupled device) opens up a whole new terra incognita for the astrophotographer. In this brief overview of goofs, I can describe only a few of the grains of sand on the immense beach of CCD mistakes.



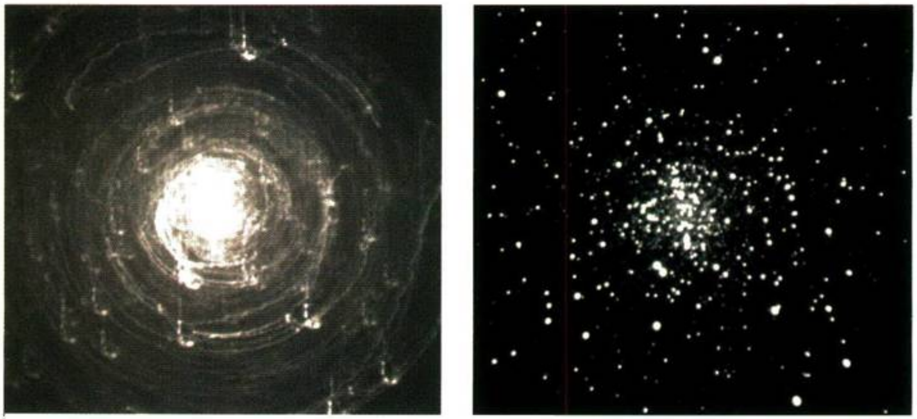
THE "ELECTRONIC MILKY WAY" is actually an image of the noise in a CCD camera that's produced when you forget to set the exposure for "light" and leave it set for "dark." This particular goof is the electronic equivalent of leaving the lens cap on when you take a picture on film.



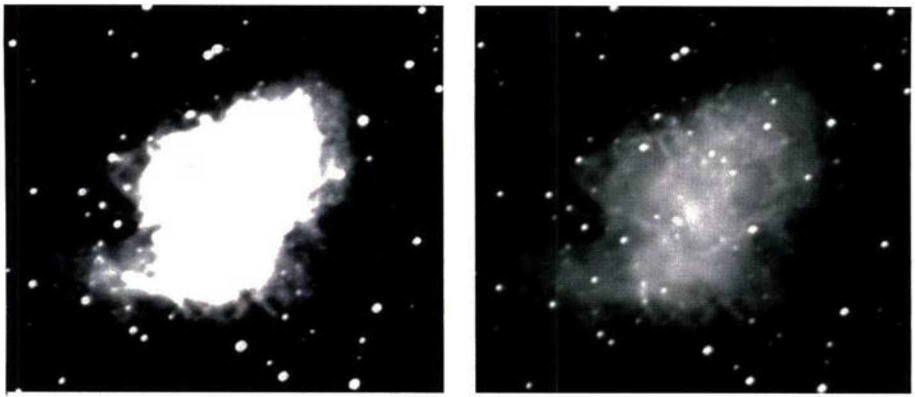
THE CIGAR GALAXY (M82) never looked so bad. An automatic-guiding CCD camera traced the fat exclamation points in the photograph as it hunted for a lost guide star.



THE STAR REGULUS (Alpha Leonis) was captured as a "nose spiral," i.e., Healy bumped the guiding eyepiece with his nose sometime during the exposure.



GLOBULAR STAR CLUSTER M4 in Scorpius is shown here as never before. The CCD image on the left was taken while the CCD camera — loosely tightened in the focuser — rotated. The image on the right was taken after the loose camera had been tightened down.



THIS IMAGE OF THE CRAB NEBULA (M1) in Taurus [left] has been flat-fielded, dark-subtracted, and adjusted in both brightness and contrast. The "burned in" section, however, contains hidden detail. **FURTHER PROCESSING** using digital development [right] reveals detail in the center of the Crab.

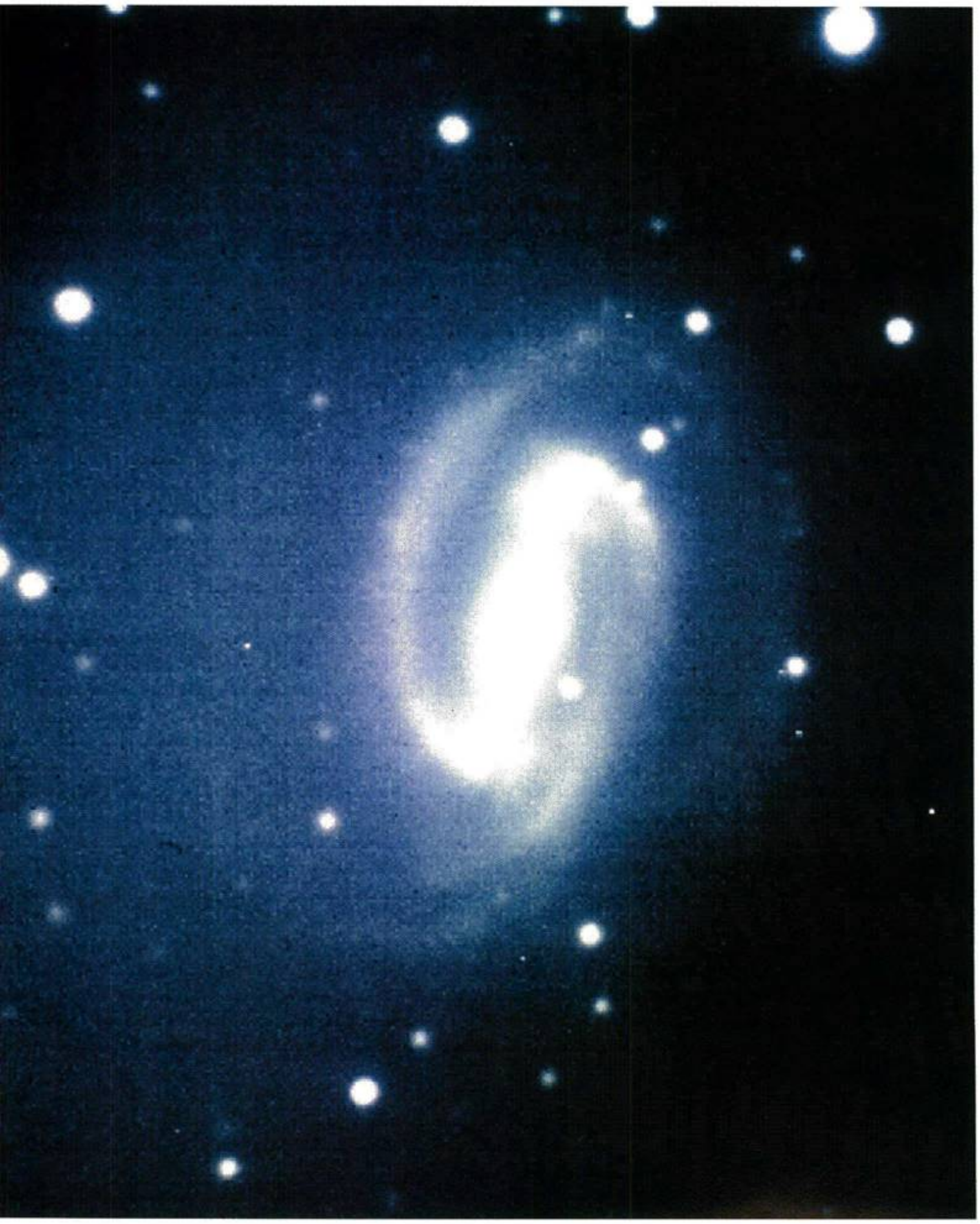
ADDITIONAL PROCESSING, making use of *Photoshop*'s kernel filters, reveals the faint outer regions of the Crab Nebula.

Some of mine are leaving the image selector on "dark frame" rather than "light frame." This digital equivalent of leaving the lens cap on produces a lovely "milky way of stars" that's actually an image of the electronic noise in your CCD.

My supreme accomplishment in bad CCD imaging is a shot of galaxy NGC 1300 (see image at left). I have dubbed it "Murphy's Galaxy" because, so far at least, I have identified seven mistakes in the image: 1) The image was not flat-fielded (the edge vignetting shows). 2) The exposure was too short. 3) The contrast was set too high (in order to compensate for underexposure, but image pixels show). 4) The image was taken at full resolution (instead of "binned," a technique that combines adjoining pixels of a CCD), wasting resolution, sensitivity, and exposure time. 5) This black-and-white image was overprocessed, so it shows a false blue color. 6) Hot pixels were not removed. 7) Detail in the original image is not displayed because advanced image-processing techniques were neglected.

The good news is that with CCD imaging, your mistakes show up in real time on your computer monitor and can quickly be corrected by either repeating the exposure or post-processing your image. Post-processing often can extract detail from an otherwise disappointing exposure.

In short, the cure for astrophotographic mistakes, whether using film or CCD, can be summed up in two words: "Try again!" Eventually (and sooner than you think), you'll succeed. ■



FOR YOUR FINAL EXAM, identify the mistakes in this CCD image of spiral galaxy NGC 1300 — at least seven exist. The answers are found in the text.

To join a discussion about astrophotography, visit www.astronomy.com/toc

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Richard Wolfson (Ph.D., Dartmouth College) is Professor of Physics at Middlebury College in Vermont. Decades of teaching at Middlebury, with its strong emphasis on the humanities, have made him an expert at demonstrating the logic and significance of physics to students from many fields. His writings have appeared in *Scientific American*, and he is the author of *Physics for Scientists and Engineers*.

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7. Einstein to the Rescue
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9. Muons and Time-Traveling Twins
10. Escaping Contradiction—Simultaneity Is Relative
11. Faster than Light? Past, Future, and Elsewhere
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19. Quantum Uncertainty—Farewell to Determinism
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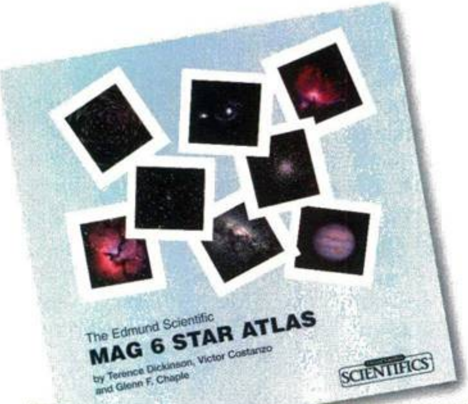
TECHNIQUES

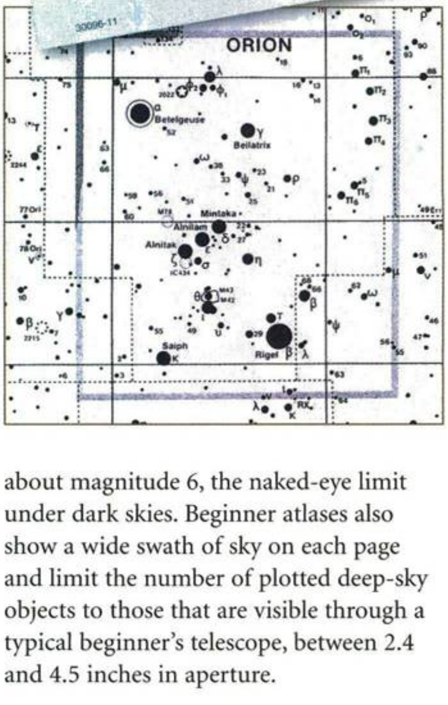
The first step toward successful observing is choosing a star atlas that's right for you.

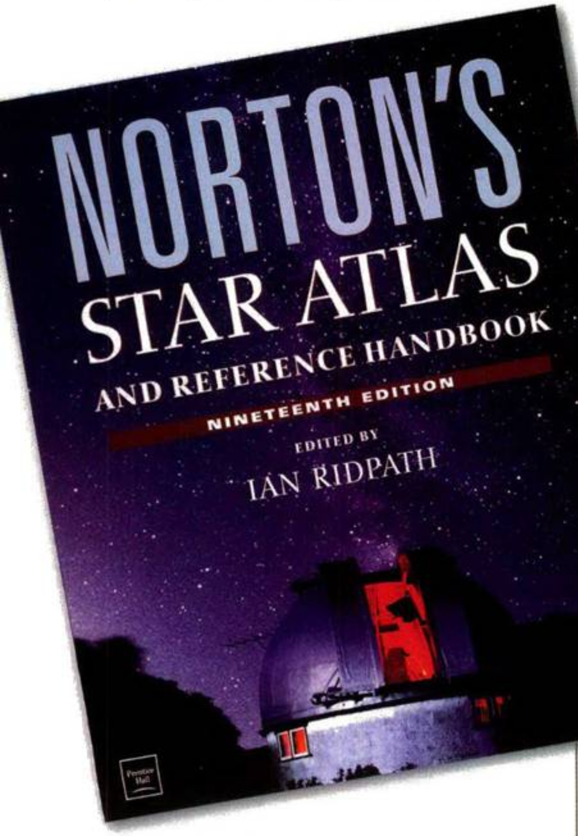
/// BY PHIL HARRINGTON

Choosing a star atlas

When most of us plan a vacation, we pore over maps and compile directions so we know how to get where we want to go. Amateur astronomers should do the same when heading out under the stars. By planning ahead, time at the telescope will be more productive and enjoyable. Find out what will be in the night sky by scanning the pages of a star atlas during the day. Even if you use a computerized go-to telescope, a star atlas tells you — at a glance — what will be visible, making your scope time more productive.


The Edmund Scientific
MAG 6 STAR ATLAS
by Terence Dickinson, Victor Costanzo and Glenn F. Chaple
SCIENTIFICS
30096-11


ORION
Betelgeuse
Bellatrix
Mintaka
Alnilam
Alnitak
IC434
M42
M43
M78
Saiph
Rigel

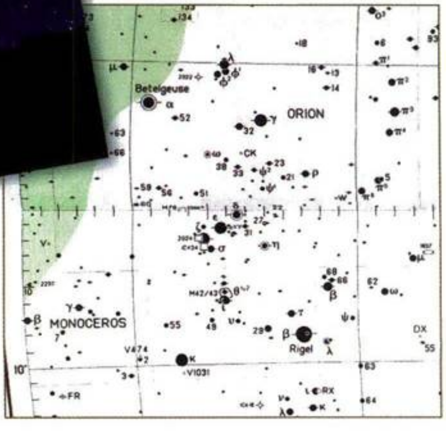

NORTON'S
STAR ATLAS
AND REFERENCE HANDBOOK
NINETEENTH EDITION
EDITED BY
IAN RIDPATH
Prentice Hall

The star atlases in print today fall into three categories based on their design, detail, and intended use: Some are best suited for use with binoculars and small telescopes; others are aimed at medium apertures; still others show the sky in sufficient detail to guide the largest backyard instruments. The best star atlas for you depends on your telescope, your goals, and your experience.

Beginner atlases

A star atlas is an all-encompassing depiction of the sky. As a result, newcomers sometimes have problems identifying constellations on star atlases. The fainter stars and telescopic objects shown on atlases that are missing on simple star maps compound these problems.

Atlases designed for beginners show only stars down to about magnitude 6, the naked-eye limit under dark skies. Beginner atlases also show a wide swath of sky on each page and limit the number of plotted deep-sky objects to those that are visible through a typical beginner's telescope, between 2.4 and 4.5 inches in aperture.


Betelgeuse
ORION
MONOCEROS
M42/43
Rigel

The sections of the star charts reproduced here are not original size. All the charts have been reduced by the same percentage; therefore, the reproductions show the differences in scale.

Norton's — a classic

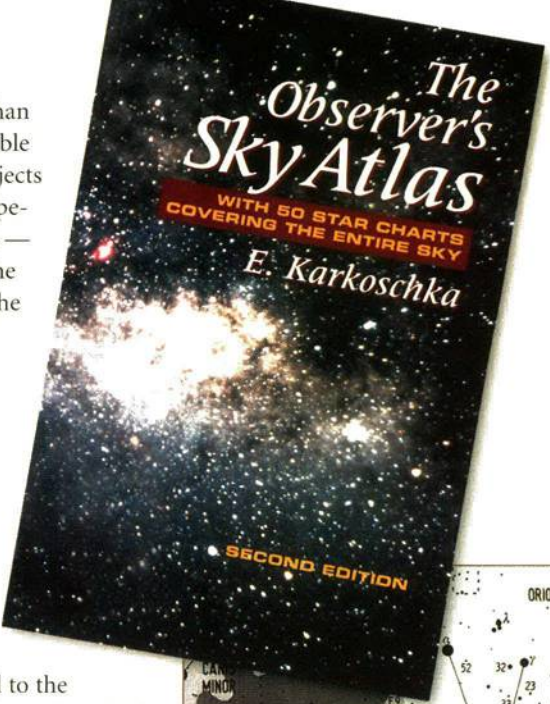
The oldest atlas in this category is *Norton's Star Atlas and Reference Handbook*, a perennial favorite ever since Arthur Norton first wrote it in 1910. *Norton's* slices up the sky into eight pieces: two circular polar charts and six rectangular, two-page charts that show the sky from declination +60° to –60°. Although constellation figures are omitted, beginners should have little trouble recognizing the more prominent star patterns thanks to the charts' ample scale.

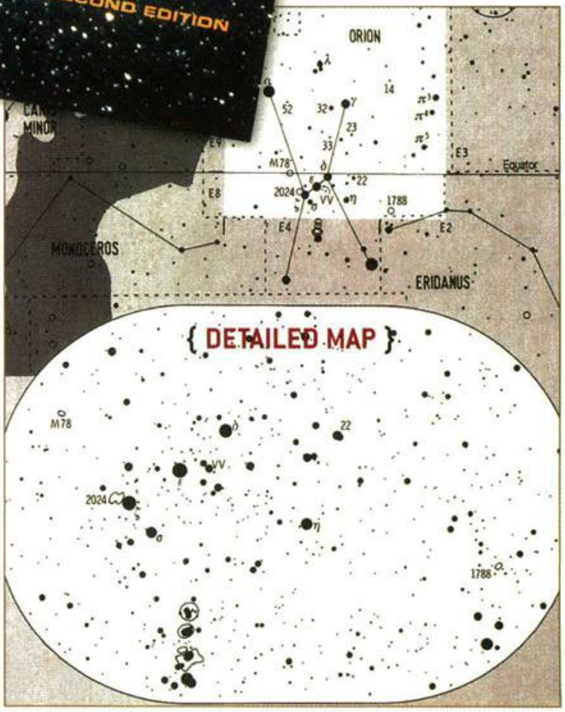
Norton's displays stars down to magnitude 6.5, hundreds of double and variable stars, and more than six hundred deep-sky objects. Lists and notes about interesting objects on each chart are included on two preceding pages. I only wish the NGC numbers on the charts were larger because I find them difficult to read under dim red light. On the plus side, *Norton's* is printed on glossy stock, which fends off dew better than more absorbent paper. Finding your way around *Norton's* is easy because each chart shows the numbers of the other charts that lie on all sides.

The bulk of the 180 pages of *Norton's* is devoted to discussions about time and positional astronomy, astronomical equipment, and how to observe celestial objects. The chapter on the solar system includes maps of the Moon and Mars, while the deep-sky chapter includes several lengthy tables of objects for observers.

An atlas from Edmund

Edmund Scientific's *Mag 6 Star Atlas* was first released in 1982. As the name suggests, the *Mag 6 Star Atlas* plots stars to 6th magnitude (actually to magnitude 6.2), as well as more than 675 double stars, variable stars, and deep-sky objects on 12 charts. Three especially crowded regions — Orion, the region of the Realm of Galaxies in the constellations Coma Berenices and Virgo, and northern Sagittarius — are detailed in close-up charts. The *Mag 6 Star Atlas* is starting to show its age, however, as each object's location is listed in celestial coordinates referenced to the year 1950. All other atlases described here are based on equinox 2000 coordinates. Printing quality is acceptable, although the small print is difficult to read at night. Also, the paper is water-absorbent, which could cause problems after repeated use in damp environments.

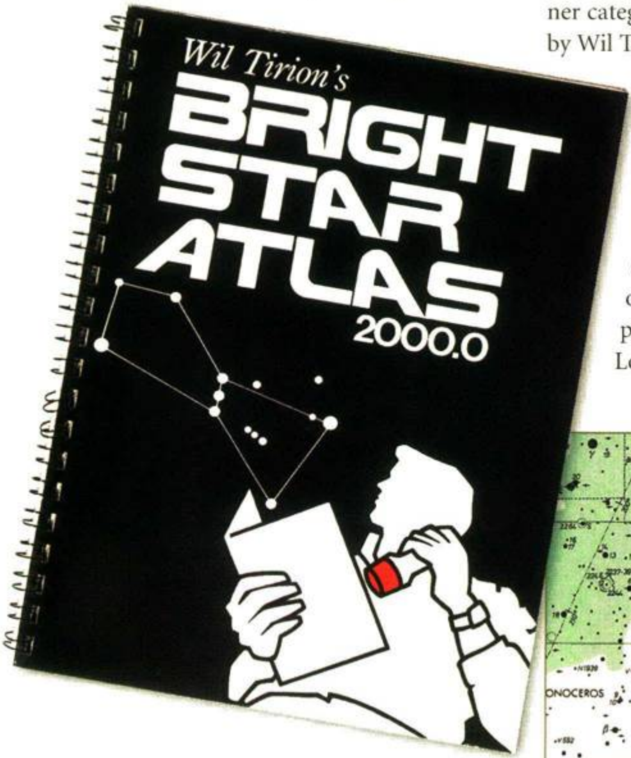


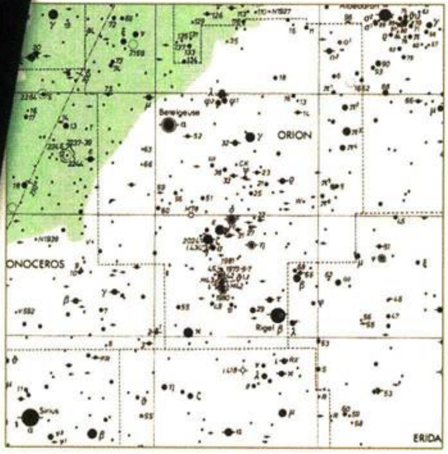


Bright stars

Another favorite atlas in the beginner category is the *Bright Star Atlas* by Wil Tirion, today's most prolific celestial cartographer. Aimed at small backyard telescopes, the *Bright Star Atlas* shows stars down to magnitude 6.5 but limits the list of plotted double stars, variable stars, and deep-sky objects to 600. The lists were compiled by coauthor Brian Skiff of Lowell Observatory.

The *Bright Star Atlas* divides the sky into four polar and six equatorial zones. Constellation boundaries — but not the figures — are plotted. Magnified inset charts are included for the Pleiades and the region around Orion's sword. I found the typeface to be small, hindering the charts' readability under dim light. A keyed series of six finder charts shows readers how the maps relate to the current night sky.





Small but mighty

The Observer's Sky Atlas created by Erich Karkoschka is by far the smallest star atlas in print, measuring only 5" by 7½" (and only ¼" thick). Its small size, however, belies the amount of information found inside. Within its 130 pages are introductory sections on deep-sky objects, discussions of celestial coordinates, magnitude,

---

Phil Harrington *is the author of the new observing guidebook* Star Watch, *which is published by John Wiley & Sons.*

size and scale, and the atlas itself, which breaks the sky into 48 charts. Stars down to 6th magnitude are plotted.

Because the book's small size could hinder reading the charts at night, each map features one or more enlarged insets showing sections that hold something of interest to observers using binoculars or 4-inch or smaller telescopes. These insets show stars as faint as 9th magnitude. Each chart is accompanied by a list of plotted objects, including Messier objects and 470 other targets. Appendices list the dates and rates of major meteor showers and data about stars, constellations, and Messier objects in tables. Lunar and planetary positional data also are included. Not bad for a book that's small enough to keep tucked in your binoculars's carrying case.

Intermediate atlases

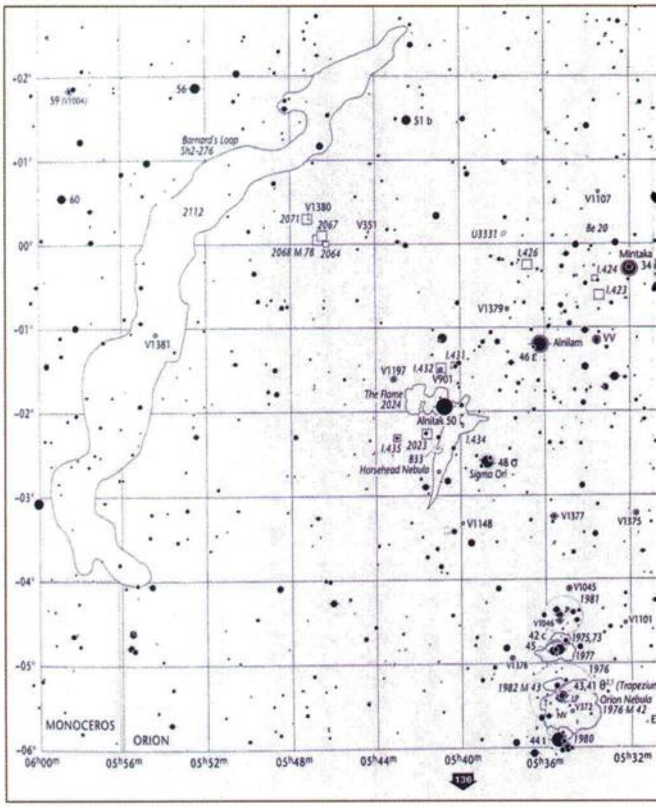
Once a beginning observer has learned the ropes of observing, it's time for a star atlas upgrade. Rather than stop at 6th magnitude and a few hundred deep-sky objects, an intermediate atlas often plots stars as faint as 8th magnitude along with several thousand deep-sky objects. To do this successfully, the atlas must show the sky at a larger scale than an atlas for beginners does. This often causes constellations to be spread across two or more charts, so the user needs to be familiar enough with the night sky to find the major constellations piecemeal on the charts.

Tirion does it again

The current standard bearer by which other stars atlases are judged is Wil Tirion's *Sky Atlas 2000.0*. The second edition, published in 1998 and coauthored by Roger Sinnott, is made up of 26 charts that show 81,312 single, multiple, and variable stars down to magnitude 8.5, as well as more than 2,700 deep-sky objects. *Sky Atlas 2000.0* also features several close-up charts, including regions around both celestial poles, fields showing the proper motions of Barnard's Star and Proxima Centauri, and detailed views of central Orion and the Coma-Virgo galaxy cluster.

Unlike any other atlas, *Sky Atlas 2000.0* is available in different versions. The "Field Version" features white stars and deep-sky objects against a black background, while the "Desk Version" plots black objects on white. Both are printed on 13.5" by 18.5" stock, unbound. The spiral-bound "Deluxe Version" features black stars and color-coded deep-sky objects (star clusters are yellow, nebulae are green, and galaxies are red) on a white background. The "Deluxe" charts measure 16" by 21" but fold into a 12" by 16" book. All editions also are available laminated.

My only complaint about the new *Sky Atlas 2000.0* is the lack of cross-referencing. Adjacent sections of the sky printed along the margins would be a nice touch.


+02°
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59 (V1004)
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51 b
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Barnard's Loop Sh2-276
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2067
V351
2068 M 78 2064
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V1107
Be 20
Mintaka 34
I.424
I.423
V1379
Alnilam
VV
46 ε
V1381
I.431
V1197
I.432
V901
The Flame 2024
Alnitak 50
I.434
I.435
2023
833
Horsehead Nebula
48 σ Sigma Ori
V1148
V1377
V1375
V1045
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V1101
42 c
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1976
1982 M 43
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Orion Nebula
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1980
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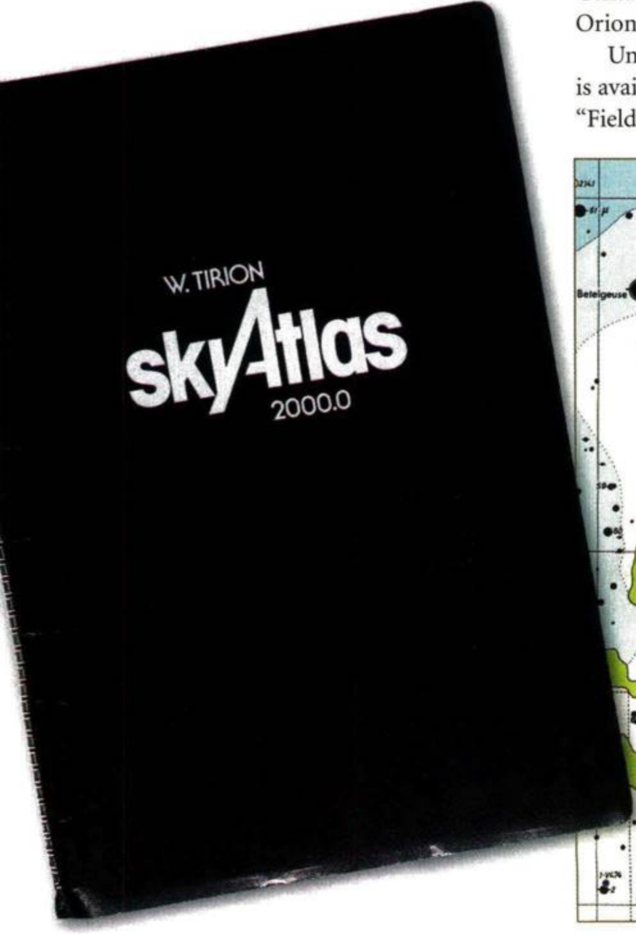
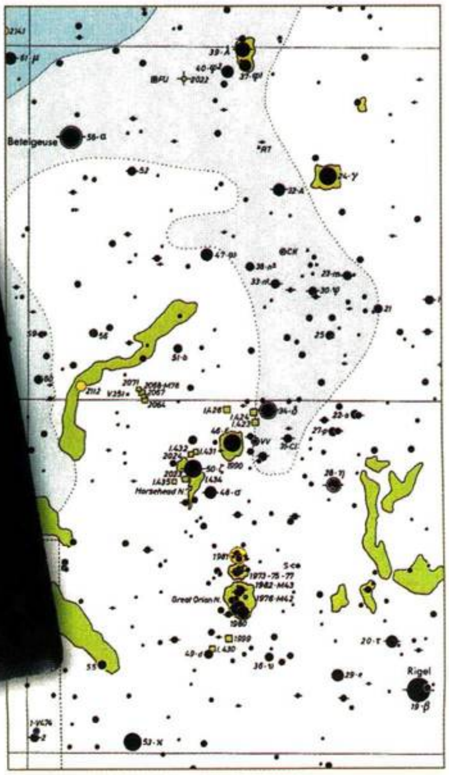

W. TIRION
skyAtlas
2000.0


Betelgeuse
Great Orion N.
Horsehead N.
Rigel

Advanced atlases

Lifelong deep-sky observers need more than *Sky Atlas 2000.0* has to offer as they probe the depths of space using telescopes with double-digit apertures. Luckily, star atlases exist that show stars down to 9th magnitude or fainter and plot tens of thousands of deep-sky objects.

Hail to the king

When it was introduced in 1987, the two-volume *Uranometria 2000.0* revolutionized star atlases — it plotted more stellar and nonstellar objects than any previous atlas readily available to the amateur astronomer. In 2001, a second edition appeared

URANO METRIA 2000.0 Volume 1
DEEP SKY ATLAS
Tirion, Rappaport, Remaklus
The Northern Hemisphere to -6°
The Southern Hemisphere to +6°
URANO METRIA 2000.0 Volume 2
DEEP SKY ATLAS
Tirion, Rappaport, Remaklus
URANO METRIA 2000.0 Volume 3
DEEP SKY FIELD GUIDE
Cragin, Bonanno
V1372
V1370
1924
Sh2-278
ORION
05h28m
05h24m
05h20m

that contains 220 double-page atlas charts. These pages collectively show more than 280,000 stars down to magnitude 9.75 and 30,000 nonstellar objects. *Uranometria* divides the sky in half, with declinations between +90° and –6° covered in volume one and +6° to –90° included in volume two. (The overlap is intentional.) The front of each volume contains a set of 22 "*Uranometria* Star Maps," which orient you to the larger atlas.

The atlas charts in *Uranometria* are organized by declination. Within each declination range, the charts flow in right ascension from east to west rather than west to east. While this sounds unimportant, it means that each chart flows across the book's binding, creating continuous two-page maps that measure 18" by 12". This greatly improves the ability to find a nearby object on an adjacent chart.

Uranometria also includes maps of selected regions whose scale has been magnified in order to show stars down to magnitude 11.5. Enlarged charts are provided for the Coma-Virgo galaxy cluster, several Abell galaxy clusters, the Large Magellanic Cloud, and areas in Cygnus, Scorpius, and Sagittarius.

Finally, there are indices listing the brightest stars and the chart numbers for all plotted deep-sky objects at the back of each volume. For even more information, a complete data listing of all objects plotted can be found in *Uranometria 2000.0 Deep-Sky Field Guide* by Murray Cragin and Emil Bonnano, sold separately.

Whether you're just beginning to find your path among the stars or are a veteran observer on a quest for that elusive 14th-magnitude galaxy, there's a star atlas just for you. Pick one that suits your needs, plan an itinerary for the next clear night, and then head outside for a great trip. Happy hunting! **A**

To learn more about star atlases, visit www.astronomy.com/toc

/// STAR ATLASES

Bright Star Atlas
Wil Tirion and Brian Skiff, 34 pages, Willmann-Bell, Richmond, Virginia, 2001; ISBN 0–943–39627–1; chart scale: 10.6° per inch; softcover, $9.95.

Mag 6 Star Atlas
Terence Dickinson, et al., 66 pages, Edmund Scientific Co., Tonawanda, New York, 2000; Edmund Scientific catalog number 30096–11; chart scale: 8.1° per inch; softcover, $19.95.

Norton's Star Atlas and Reference Handbook
Ian Ridpath, editor, 19th edition, 180 pages, Prentice Hall, New York, 1998; ISBN 0–582–35655–5; chart scale: 7.2° per inch; softcover, $31.95.

The Observer's Sky Atlas
Erich Karkoschka, 130 pages, Springer-Verlag, New York, 1998; ISBN 0–387–51588–7; main chart scale: 12.5° per inch; close-up insert charts vary in scale; softcover, $22.95.

Sky Atlas 2000.0
Wil Tirion and Roger Sinnott, 2nd edition, 26 charts, Sky Publishing Corporation, Cambridge, Massachusetts, 1998; ISBN 0–521–65431–9 (Field Edition), 0–521–65433–5 (Desk Edition), 0–521–62762–1 (Deluxe Edition); chart scale: Field and Desk editions: 3.6° per inch; Deluxe Edition: 3.2° per inch; softcover, $30 (Field or Desk edition); softcover, $50 (Deluxe Edition).

Uranometria 2000.0
Wil Tirion, Barry Rappaport, and Will Remaklus, Willmann-Bell, Richmond, Virginia, 2001, 370 charts, ISBN 0–943–39671–9 (volume 1, Northern Hemisphere); 0–943– 39672–7 (volume 2, Southern Hemisphere); 0–943–39673–5 (volume 3); chart scale: 1.4° per inch; hardcover, $49.95 (volume 1 or volume 2); hardcover, $59.95 (volume 3).

Note: Chart scales measured at the celestial equator.

TELESCOPE REVIEW

The new Maksutov-Cassegrain telescope by Konus is a fine performer with a good feel.

/// BY MIKE MARCOTTE

Konus's new Mak-Cass

THE CONTROL PADDLE for the Konus Motormax-130 HM allows variable speed directional control of two axes. ASTRONOMY: JAMES FORBES

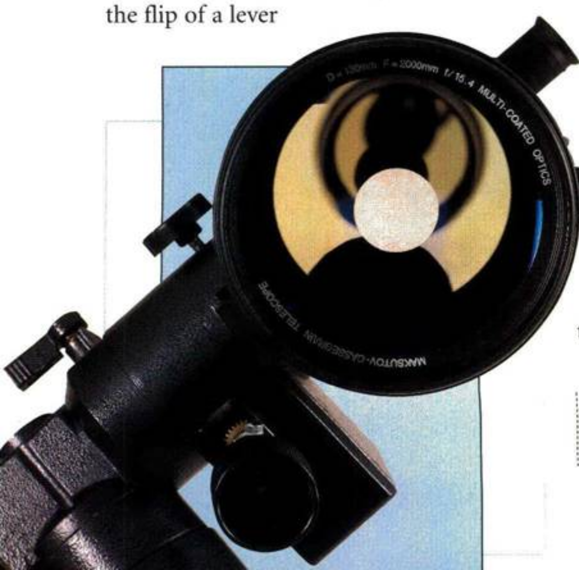
In October 2003, I had the opportunity to review Konus U.S.A. Corp.'s new 5.1-inch (130mm) f/15.4 Maksutov Cassegrain (Mak-Cass) telescope. Designated the Motormax-130 HM, this scope features a 2000mm focal length, multi-coated optics, and a German equatorial mount with dual-axis motor drives. Included in the $569 package are an aluminum tripod, an 8x50 finder scope, 10mm and 17mm Plössl eyepieces, a polar scope, and a Moon filter. Test locations varied from my light-polluted urban backyard to the ink black skies of rural New Mexico, so the Motormax-130 HM got to see the full range of sky quality.

Overview

Let's start with the telescope's tube. Manufactured in China, it has a clean, efficient, rugged appearance with a length of just 17.5 inches and a whopping 2000mm focal length. A large, user-friendly 1.75-inch focus knob is partially inset at the rear edge of the tube. This inset allows room for the star diagonal to be rotated without hindering the operation of the focus knob, which is smooth and precise.

A movable, internal diagonal mirror at the rear of the tube allows you — with the flip of a lever — to view either from an eyepiece holder at the end of the scope (as with a conventional Mak-Cass) or from a second eyepiece holder located on the side at the rear of the tube. This well-thought-out feature allows you a potentially more comfortable position when viewing objects high in the sky. It also allows you to mount two different eyepieces at the same time. I found this especially helpful when viewing planets. By putting a different color filter on each eyepiece (or leaving one eyepiece with no filter), I could compare the two images almost instantly. The Konus Motormax-130 HM comes with a 45° star diagonal, which makes it somewhat difficult to use the rear portal for high sky-objects. A 90° diagonal would be a nice addition.

Konus provides two Plössl eyepieces, a 17mm and a 10mm, with this scope. I would have preferred a 25mm or 26mm to go with the 10mm. The 17mm yields almost 120x, which reduces the field of view to the point where positioning an object within that field is more difficult than it would be with a 25mm eyepiece. However, the excellent 8x50 finder scope offsets this problem somewhat. With a finder scope of this size and quality, it was easy to find and center objects once I aligned the finder properly. The finder scope is attached to the main tube with a dovetail mount and comes with a holder that has six alignment screws. Some newer finder scope brackets use just two screws and a spring-loaded pin to hold and align the finder scope. That type of holder is easier and faster to align than the older six-screw type, so an upgrade in this area is something to consider.

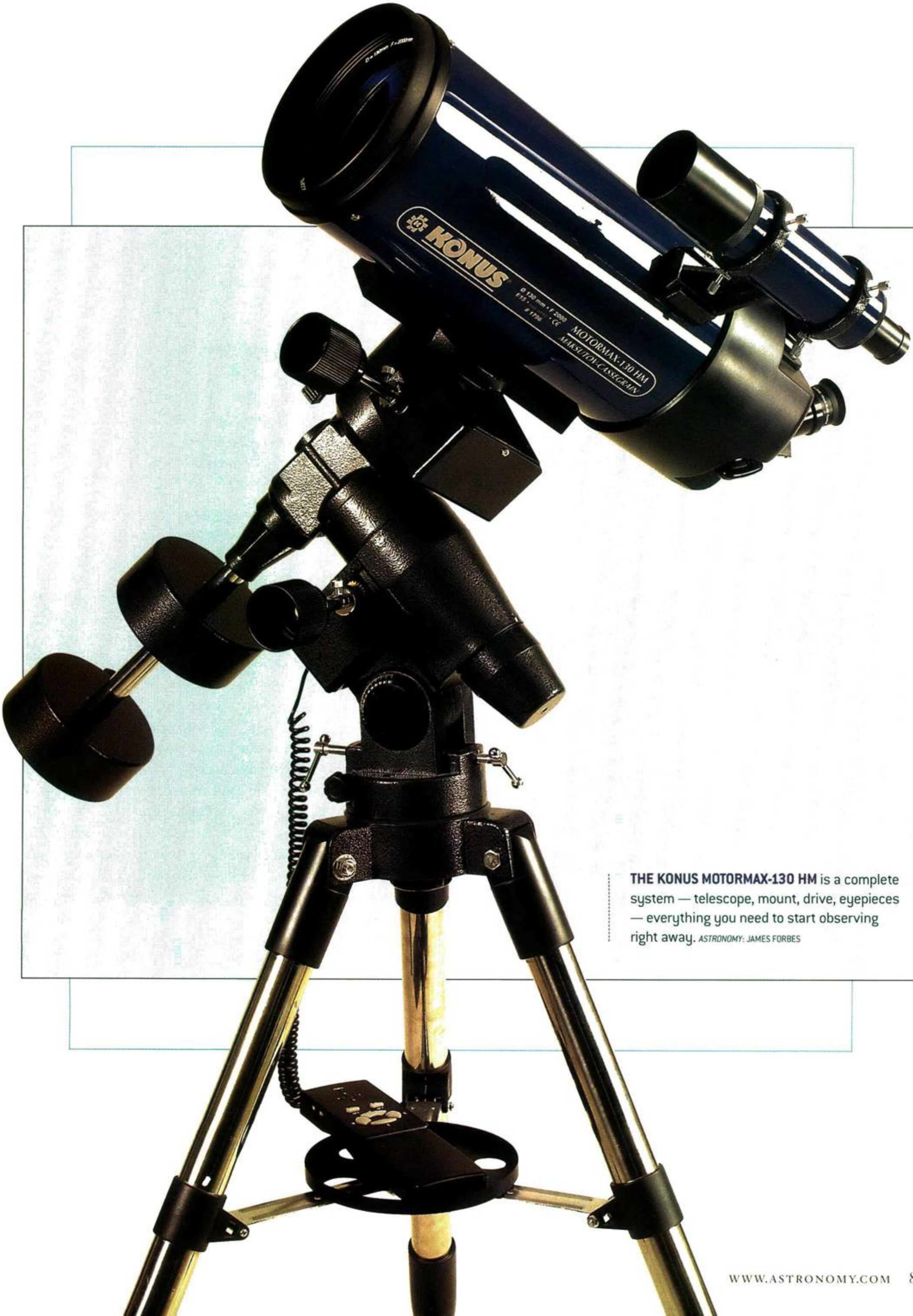

D=130mm F=2000mm f/15.4 MULTI-COATED OPTICS
MAKSUTOV-CASSEGRAIN TELESCOPE

THE KONUS Maksutov-Cassegrain incorporates a front corrector lens, on which the secondary mirror is mounted. ASTRONOMY: JAMES FORBES

Mount and drive

The German equatorial mount for this telescope is nice and sturdy, and the operation of both the right ascension (R.A.) and declination (Dec.) axes is firm and smooth with very little "slop" in the gears. The large R.A. and Dec. locking levers are easy to locate and operate. The slow motion controls are short with large knobs and have a smooth feel. The motors are integrated into the mount and are geared for tracking only. All major movements of the scope must be made manually.

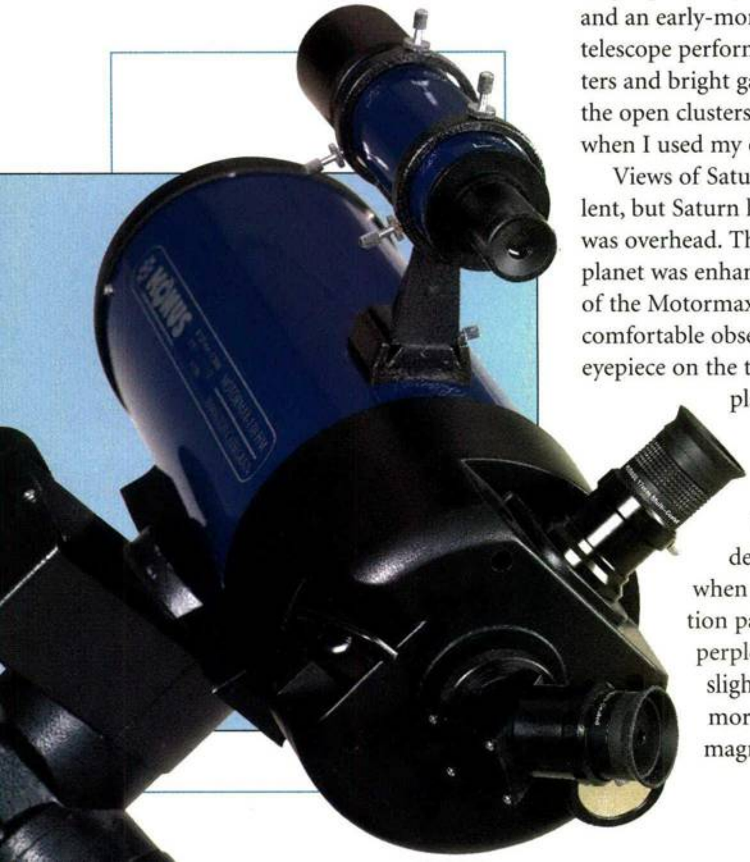
The motors are powered and controlled by a paddle that uses six AA batteries and has four push buttons to activate the motors for north, south, east, and west. There are also two "off" buttons, one for each motor. When one of the directional


KONUS
MOTORMAX-130 HM
MAKSUTOV-CASSEGRAIN

THE KONUS MOTORMAX-130 HM is a complete system — telescope, mount, drive, eyepieces — everything you need to start observing right away. *ASTRONOMY*: JAMES FORBES buttons is pressed, the only way to turn that motor off is to press either the N–S or W–E off button. I like this feature because it reduces the chance of shutting a motor off accidentally. On the side of the control paddle is a dial used to change the tracking speed of each motor. A master switch powers the paddle and, when activated, is indicated by a red LED. All other paddle functions have green LEDs to indicate which function is being used. These LEDs created a problem I discovered after I had set up under a dark sky. The LEDs are so bright they affected my dark adaptation, not to mention the attention they drew from fellow star party attendees nearby. I quickly solved the problem by stuffing the paddle into a cloth bag I had handy. Not a big deal, but it's worth mentioning.

The mount has a nice built-in polar scope that can be used for either northern or southern latitudes. I didn't polar align the scope accurately because I wasn't using setting circles to find objects or doing astrophotography. I just used the polar scope to get the alignment close.

TWO EYEPIECES can be mounted in the Konus Motormax-130 HM at the same time. The lever (to the left of the lower eyepiece) directs the image into either eyepiece. This feature is great for comparative views with filters or using eyepieces yielding different magnifications. *ASTRONOMY*: JAMES FORBES



Lastly let's look at the tripod. Although lightweight, it is adequately stable. I especially like two features on this tripod. The first is the spike at the foot of each leg. Each spike has a soft rubber cap that helps prevent movement (and some vibration) when the scope is set up on a hard surface like concrete or asphalt. On soft ground, you can remove the rubber caps and push the spikes into the ground for stability. The second feature on this tripod that I like is the eyepiece tray that has a single, integrated bolt that screws directly into the center of the leg support. This speeds up the process of attaching the tray and eliminates the use of loose nuts and bolts, which are so easily misplaced.

Under the starry sky

The Mak-Cass is a popular telescope design because it delivers quality views in a compact package. This scope is no exception. I found the optics to be excellent. The contrast was surprisingly good under all sky conditions, and the image was sharp and clear from edge to edge. The desert southwest offers many great dark-sky locations from which to observe a large variety of objects, and the Motormax-130 HM performed remarkably well.

Keeping in mind the limitations of a 5.1-inch aperture, I moved through galaxies, globular clusters, open clusters, some bright planetary nebulae, Mars, Saturn, and an early-morning Jupiter. I found the telescope performed best on globular clusters and bright galaxies, although some of the open clusters really strutted their stuff when I used my own 40mm eyepiece.

Views of Saturn and Jupiter were excellent, but Saturn looked better because it was overhead. The view of the ringed planet was enhanced further by the ability of the Motormax-130 HM to give me a comfortable observing angle through the eyepiece on the tube's side. Most of the planetary nebulae I observed were 9th magnitude or brighter. These objects were visible but indistinct. I detected a loss of sharpness when pushing the magnification past 200x, which initially perplexed me. The cause was a slight image shift that was more noticeable at higher magnifications. A quick touch of the focus knob made re-obtaining a sharp image easy.

/// PRODUCT SPECS

Konus Motormax-130 HM 5.1-inch f/15.4 Maksutov-Cassegrain reflector

Weight: 62 pounds total

Tube length: 17.5 inches

Eyepieces: 10mm and 17mm Plössl

Finder scope: 8x50

Mount: German equatorial

Also included: Dual-axis motor drive with hand controller, polar axis finder, steel tripod

Cost: $569

Contact information

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Go-to or not?

I would like to interject a few words about non-computerized equatorial mounts, like the one this scope is mounted on. On the one hand, to use an equatorial mount to its fullest potential, you need to understand some concepts of coordinate systems and develop both a knowledge of star locations and the technique of star hopping. For those who desire to understand and master these concepts and skills, an equatorial mount is fine. On the other hand, computer-driven scopes have eliminated the need to learn alignment skills and the equatorial coordinate system. So if you don't want to spend time learning those skills and concepts, an equatorially mounted, non-computerized scope would probably not be a good idea for you.

All in all, the Konus Motormax-130 HM offers high-quality optics in a handsome tube. The dual eyepiece feature is interesting and useful. The mount is stable with a tight, smooth, well-machined feel. The high-quality 8x50 finder scope is a definite plus. This complete telescope system is all you need to get started observing the Moon, planets, and deep-sky objects.

Mike Marcotte *is an amateur astronomer and retired firefighter who observes from the clear, dry skies of El Paso, Texas.*

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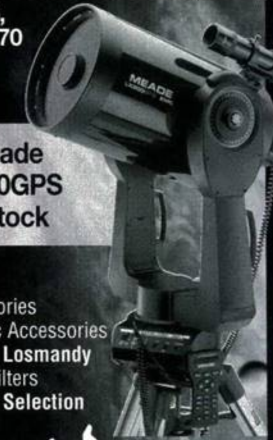

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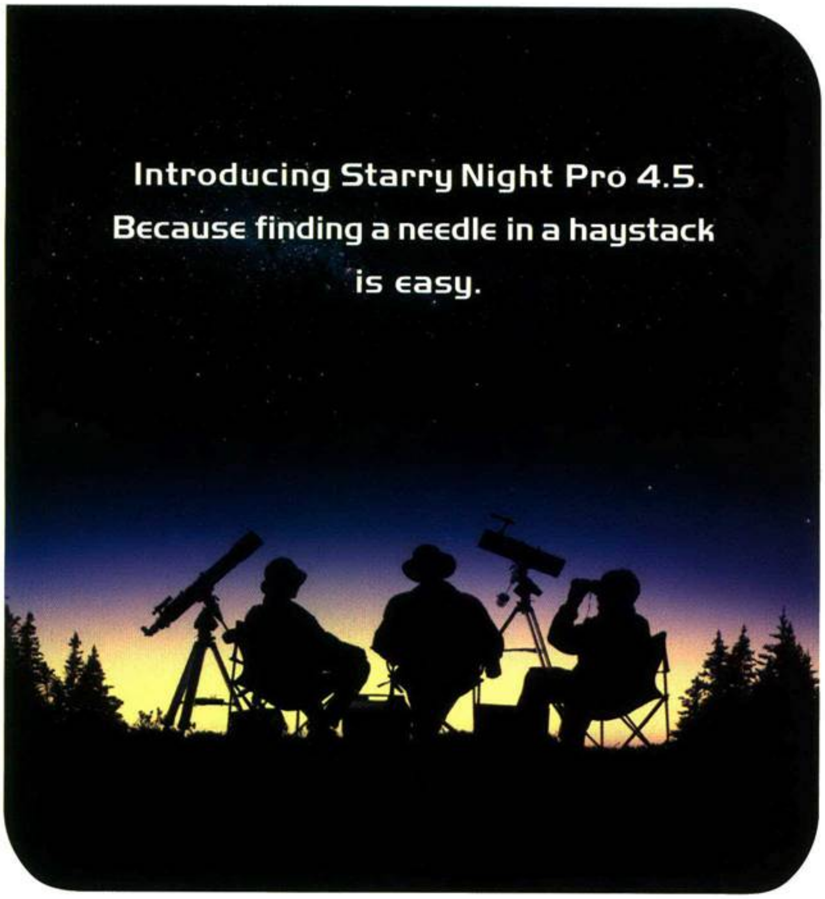
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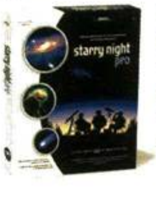

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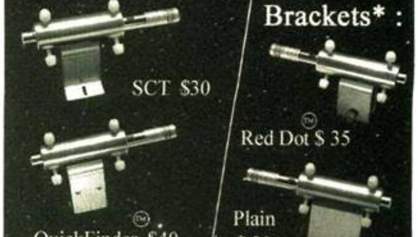

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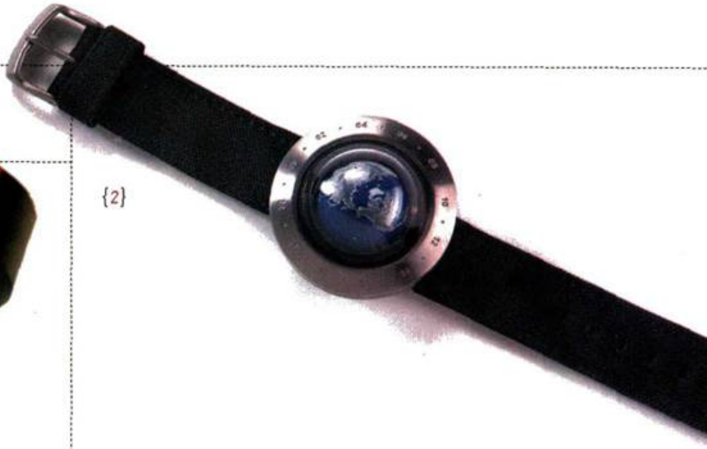

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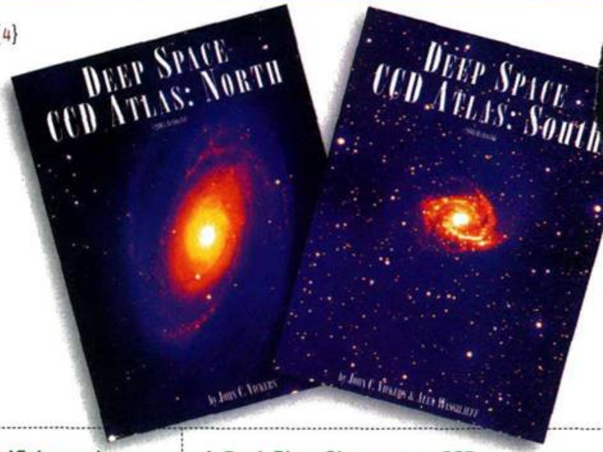

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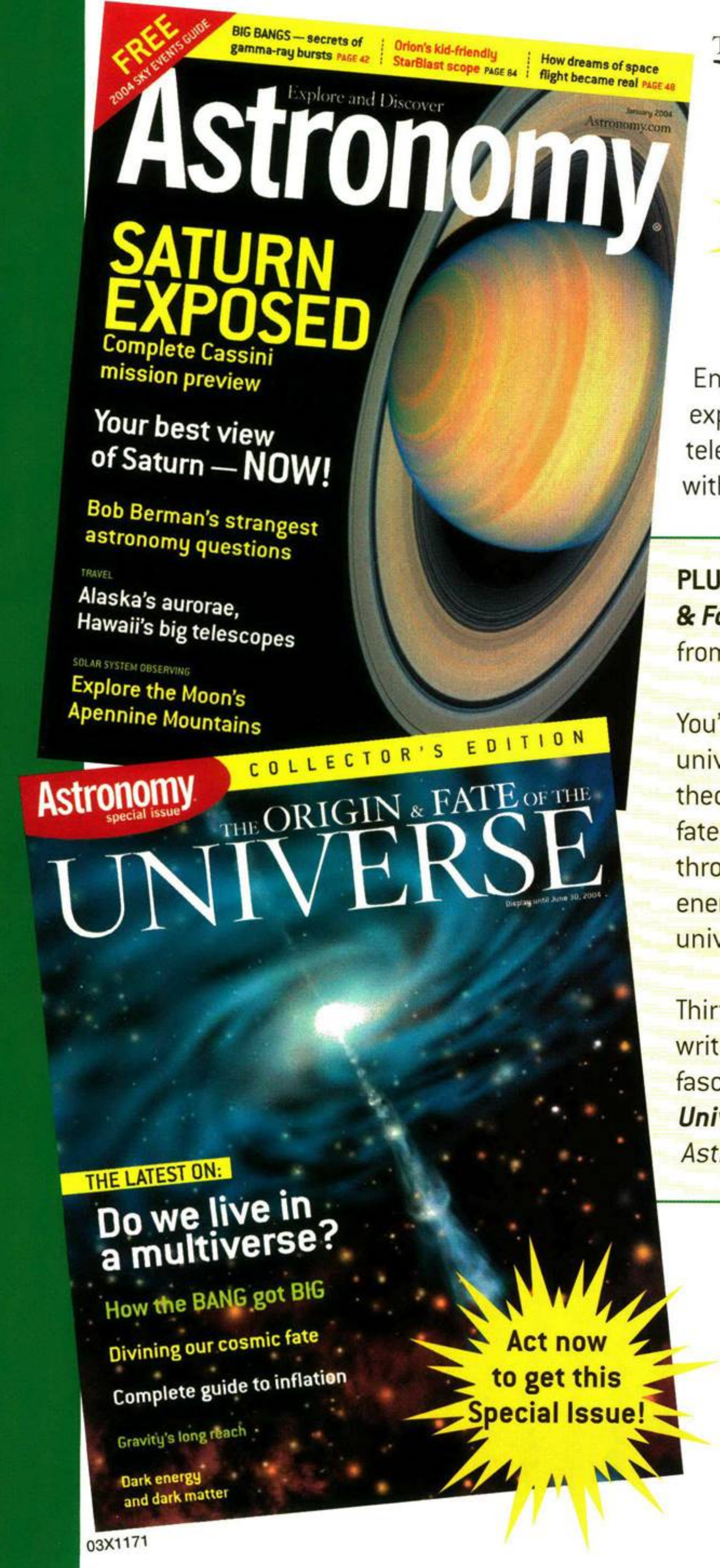
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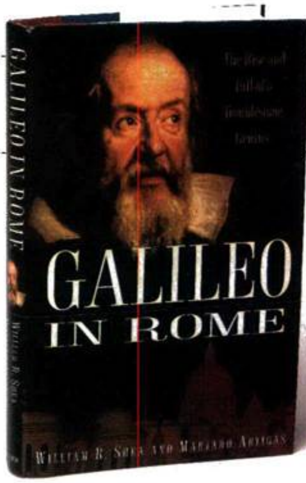
Did Galileo create his own troubles?



Galileo in Rome

William R. Shea and Mariano Artigas, 226 pages, Oxford University Press, New York, 2003; ISBN 0-19-516598-5; hardcover, $28.

Galileo in Rome is a brilliantly documented and fresh account of Galileo's Copernican defense and his subsequent entanglement with the Roman authorities.

Not a biography in the normal sense, this book concentrates in rich detail on Galileo's many connections, interactions, and tensions with the Vatican. The dramatic story of his trial and house arrest is all too often told in terms of black and white. In contrast, Shea and Artigas paint a picture in carefully nuanced grays.

The arrangement of their new book is particularly ingenious. Each of the six chapters concentrates on one of Galileo's trips to Rome. They begin with a visit in 1587, when Galileo was a young job-seeker, and end with his forced journey in 1633, when he faced trial by the Inquisition. Galileo's second visit to Rome came in 1611 after his initial telescopic discoveries. It was a triumphal tour with his spyglass in hand, and he left with a new name for it: telescope. The authors refer to his third visit, in 1616, as his "first trial," even though it seemed there was no direct legal action against him then on account of his active defense of the motion of Earth.

While reading, I discovered my own past retelling of the Galileo story has been flawed in various details. Thus, although Galileo had six audiences with the new Pope Urban VIII, when he went to Rome in 1624 (his fourth trip), he came away without explicit permission to write a book about the Copernican cosmology. Nevertheless, Galileo believed the coast was clear for him to discuss the heliocentric system despite the warning he had received in 1616. I had further imagined that during the fourth visit to Rome, the pope had directly instructed Galileo that the title of his proposed book could not refer to the tides, which Galileo erroneously considered a physical proof of Earth's motion. But the prohibition actually was conferred at a late stage by one of the censors, even after Galileo's fifth trip (1630), when he had gone to the Holy City to arrange a license for the publication of his *Dialogue on the Two Chief World Systems.*

Because the journeys to Rome form the backbone of any account of the "Galileo affair," the inspired choice of these six visits gives the book a clear focus. It also allows the authors to lay out a virtually complete account of these critical moments without producing a work of burdensome length. The documentation is excellent. The authors use quotations from letters to and from Galileo, third-party correspondence, and opinions and gossip.

What emerges is that despite the traditional "martyr of science" reading, and despite Galileo's anger at his treatment by the Roman authorities, there is good evidence that the Catholic Church handled him with exceptional sensitivity. The authors make it clear that Galileo was on the right track to become "the founder of modern science." But they argue there was little way for the authorities, with a blinkered view of the changes taking place, to understand Galileo's mode of thinking. He was changing the rules of science.

Furthermore, the situation was greatly complicated by tensions between Spanish and French cardinals, who were almost literally at knife points because of the Thirty Years War, while Catholic theologians were trying to maintain a united front against the Protestants.

In recent decades, two provocative interpretations have enlivened discussions of the Galileo affair. In *Galileo Heretic* (1987), Pietro Redondi suggested, on the basis of new documents he found in the Vatican Archives, that Galileo's atomism — and its implication for the interpretation of the Eucharist — was the real cause of his troubles with the Vatican. The Copernican charges were merely a coverup. *Galileo in Rome* gives this issue rather short shrift, as have most scholars since Redondi's book appeared.

Earlier, in *The Crime of Galileo* (1955), Giorgio de Santillana argued that the 1616 injunction against Galileo by the Inquisition was actually a forgery. Shea and Artigas accept the document as genuine, but they argue that it lacked efficacy because it had not been notarized, a position I long accepted. However, recently, Francesco Beretta reexamined the matter and concluded that such injunctions did not have to be notarized to be enforced.

The injunction forbade Galileo from teaching Copernicanism in any way, whereas a letter he subsequently obtained from Catholic theologian Robert Bellarmine merely warned him against holding the Copernican doctrine; Beretta suggests that, as a matter of strategy, Galileo conveniently forgot the injunction and clung to the letter instead.

Thus, despite the excellence of *Galileo in Rome*, the last words on the Galileo affair remain to be written. In any event, it's clear that while Galileo was brought to trial for a "vehement suspicion of heresy," he was sentenced to house arrest not for heresy but for disobeying orders.

— **OWEN GINGERICH** *is professor of astronomy and history of science at the Harvard-Smithsonian Center for Astrophysics.*

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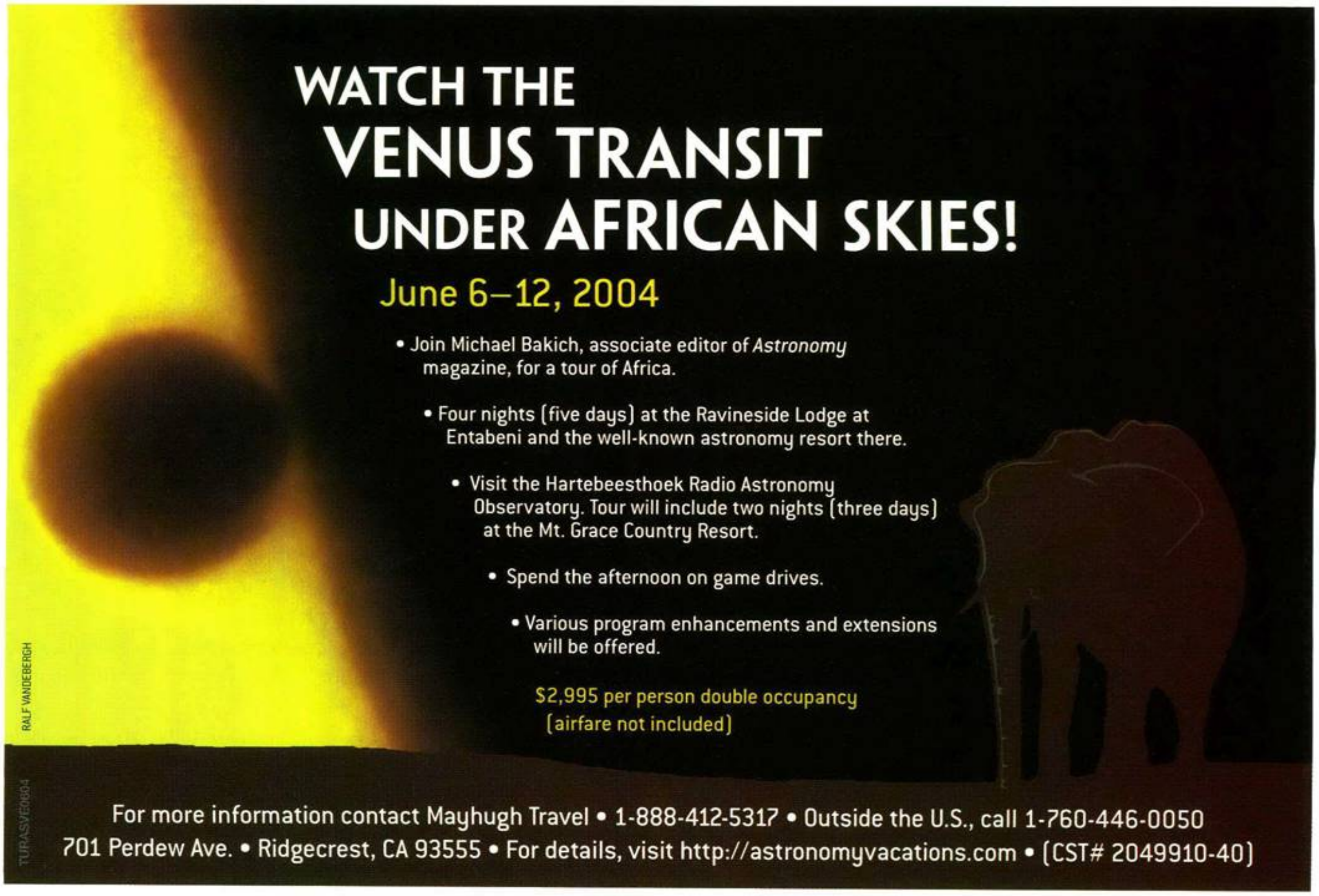

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06.16.04–06.21.04

Formerly held at Lassen Volcanic National Park, the Shingletown Star Party was moved to the Shingletown Airport in 2002 in response to increasing attendance. This year even more participants are expected to view the skies at this northern California star party.

SHINGLETOWN STAR PARTY attendees crowded this section of the Shingletown Airport runway in 2003 with their telescopes and camping accommodations. MIKE MAYDA

Each year, seasoned veterans and novices of astronomy gather on the Shingletown Airport's runway for day and nighttime observing. As with many other star parties, attendees will find workshops, lectures, and vendors at Shingletown.

While the dark skies and camaraderie bring amateur astronomers back each year, other attractions make Shingletown a popular gathering. The Shingletown area offers many shops, flavorful historical attractions, hiking, and fishing in its many bodies of water.

For more information, e-mail info@shingletownstarparty.org; web site, www.shingletownstarparty.org.

04.17.04–04.18.04

Northeast Astronomy Forum and Telescope Show

Rockland Community College, Suffern, New York. This annual gathering features observing, workshops, lectures, and many exhibitors. *Astronomy* associate editor Michael Bakich will be in attendance. For more information, visit www.rocklandastronomy.com.

05.07.04

Far Out Friday

Adler Planetarium, Chicago. On the first Friday of every month, the Adler hosts an evening of observing and education. Experts will be on hand to answer questions and help visitors using a telescope. For more information, visit www.adlerplanetarium.org.

05.14.04–05.16.04

Southern Star Astronomical Convention

Wildacres Retreat, near Little Switzerland, North Carolina. The Charlotte Amateur Astronomers Club will host this 17th annual event near the Blue Ridge Mountains. This year's speakers include amateur comet hunter Howard Brewington, a member of the Sloan

Explore and Discover Astronomy

NEXT MONTH

Great comets

Not long ago, Hale-Bopp and Hyakutake reminded us how spectacular comets can be. Yet these cosmic visitors represent only an iceberg's tip of history's great comets.

To Mars, via the Moon

President Bush announces the boldest initiative in space exploration since Apollo — building a Moon base as a stepping-stone to Mars. Can it be done? Take a look at what's in store.

Springtime comets

The spring sky should provide two bright evening comets for backyard observers to see with telescopes, binoculars, or their naked eyes.

Exploring Mars

Check out the latest images and results from the Red Planet returned by NASA's Mars Exploration Rovers.

Fireball hunt

A collection of cameras called the All-Sky Fireball Network has its tireless eyes pointed to the sky 24 hours a day searching for brilliant meteors. This co-op hopes to plot a fireball fall accurately enough to recover a specimen.

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Digital Sky Survey Observation Team at Apache Point Observatory in Sunspot, New Mexico, and Antique Telescope Society founder Bart Fried. For more information, contact Darrel Keener, 4826 Currituck Drive, Charlotte, NC 28210; e-mail David Friday at davidfriday@vnet.net; web site, www.charlotteastronomers.org.

05.20.04–05.24.04

Mason-Dixon Star Party

Codorus State Park, near Hanover, Pennsylvania. The 14th annual Mason-Dixon Star Party will be hosted by the York Astronomical Society. This popular event will feature observing, workshops, swap tables, and a 24-hour food catering service. For more information, visit masondixonstarparty.org.

05.24.04–05.27.04

Frozen Banana Star Party

Munro Park, near Powassan, Ontario, Canada. Sponsored by the Sudbury Astronomy Club, this is a biannual event, with the other gathering held in autumn. One of the more eccentric star parties in North America, participants will be treated to banana dishes and banana-themed surprises. For more information, contact Harold Healy at 8 Shelley Drive, Sudbury, Ontario P3A 2S5; call, 705.524.1524; e-mail, hhealy@sympatico.ca; web site, www.sudburyastronomy.com.

05.27.04–05.30.04

Meeting on Asteroids and Comets in Europe

Frasso Sabino, Italy. Scientists will convene at this meeting to discuss minor bodies traveling through the solar system. Related topics will include advances in telescope design, observing methods, and remote observation systems. For more information, e-mail mc3657@maclink.it.

05.28.04–05.30.04

Riverside Telescope Makers Convention

YMCA Camp Oakes, near Big Bear City, California. Located in the San Bernardino mountains, the site offers dark skies at a high altitude. *Astronomy* associate editor Michael Bakich will be in attendance. For more information, visit www.rtmcastronomyexpo.org.

06.18.04–06.19.04

Craters of the Moon Star Party

Craters of the Moon National Monument, near Arco, Idaho. Named for its resemblance to the lunar landscape, this site was formed by huge lava flows. Besides observing, participants may take part in the many outdoor activities available, such as hiking, bird-watching, and lava-formation exploring. For more information, contact Lowell Frauenholz at 208.588.3133; e-mail, misty60@pcif.net.

07.09.04–07.18.04

Summer Star Party

Shady Pines Campground, Savoy, Massachusetts. This dark-sky location offers grassy observing fields at a high elevation. All campsites have water access and electric hook-ups. For more information, contact Don Urban at 73 Haring Street, Closter, NJ 07624; phone, 201.768.6575; e-mail, SummerStarParty@rocklandastronomy.com; web site, www.rocklandastronomy.com.

07.20.04–07.24.04

AstroCon

Mills College, Oakland, California. Cosponsored by the Astronomical Association of Northern California and the Eastbay Astronomical Society, this gathering will concentrate on observing and bringing the wonders of the night sky to the public. For more information, visit www.astrocon2004.org. ■

CONTACT INFORMATION

Please submit club announcements four months in advance to Coming Events, *Astronomy*, P. O. Box 1612, Waukesha, WI 53187, or jmcgovern@astronomy.com. Add your events to our on-line calendar at www.astronomy.com.

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RESOURCES

Learn more about this issue's topics:

DESTINATION: MARS

BOOKS — A voluminous amount of literature about Mars exists, and that's just counting recently published material. Ken Croswell's new pictorial book, *Magnificent Mars* (Free Press, New York, 2003), is an excellent choice. He provides a wealth of photos — taken both from orbit and the planet's surface — plus a highly detailed map to orient the reader.

An earlier work by Paul Raeburn, *Mars: Uncovering the Secrets of the Red Planet* (National Geographic Society, Washington, D.C., 1998), focuses heavily on NASA's highly successful Pathfinder mission to Mars in 1997. For a fascinating look at the engineering effort and diverse personalities behind Pathfinder's little rover, see Andrew Mishkin's *Sojourner* (Berkeley Books, New York, 2003).

For an historical account of Earth-based Mars studies up to the Mars Global Surveyor era, read *Mars: The Lure of the Red Planet* by William Sheehan and Stephen James O'Meara (Prometheus Books, Amherst, New York, 2001).

On a different note, *Mars on Earth* by Robert Zubrin (J. P. Tarcher/Penguin, New York, 2003) narrates an experiment in which researchers, simulating a base on Mars, lived in a cramped module in the Canadian high arctic.

For a detailed, scientific look at how the planet formed and evolved, pick up *The Smithsonian Book of Mars* by Joseph Boyce (Smithsonian Institution Press, Washington, D.C., 2002). Finally, a handy, pocket-size Mars guide written by renowned planetary scientist William K. Hartmann is *A Traveler's Guide to Mars* (Workman Publishing, New York, 2003).

WEB — Check out different space agencies' web sites for the latest on their respective missions. For the European Space Agency's Mars Express, see *www.esa.int/export/SPECIALS/Mars_Express/index.html.* For their Beagle 2 lander, see *www.beagle2.com/index.htm.* Don't miss NASA's page on the two Mars Exploration Rovers (MERs). Find the site for Spirit, which landed in Gusev crater, and Opportunity, which is targeted to land in Meridiani Planum, at *marsrovers.jpl.nasa.gov/home/index.html.* The main "portal" at the Jet Propulsion Laboratory for all its Mars missions is *mars.jpl.nasa.gov.*

ENVISIONING MARS

WEB — Kees Veenenbos's web site with more illustrations of Mars is at *home-1.worldonline.nl/~veenen/terragen/mars/mars.html.* Find an interview with the artist at *www.imagiverse.org/interviews* under "engineering and technology."

To create his images, Veenebos uses two software packages: *Terragen* is available at *www.planetside.co.uk* in versions for both Mac and Windows platforms; *3DEM*, which is available for Windows only, is located at *www.visualizationsoftware.com/3dem.html.*

THE LOST YEARS OF MICHAEL TURNER

ARTICLES — To learn more about dark energy, the mysterious yet abundant force holding our universe together, read "Will dark energy steal all the stars?" by Steve Nadis (*Astronomy*, March 2003).

For Michael Turner's take on the strangeness of our cosmos, check out "Absurd universe" (*Astronomy*, November 2003). For other opinions on the state of our universe, take a look at "Zillions of Universes? Or Did Ours Get Lucky?" by Dennis Overbye (*The New York Times*, October 28, 2003).

WEB — For more information about Michael Turner's research in theoretical astrophysics and cosmology, go to *physics.uchicago.edu/t_astro.html.* This page also includes a link to his essay "Limits to our arrogance," which discusses the necessity for cosmologists' audacity.

For a comprehensive history of developments in cosmology, visit *en2.wikipedia.org/wiki/Timeline_of_cosmology.*

JUPITER AT ITS BEST

BOOKS — An outstanding guide to Jupiter's atmospheric features is the comprehensive, heavily illustrated *The Giant Planet Jupiter* by John H. Rogers (Cambridge University Press, New York, 1995). To find out more about recent discoveries, read *Mission Jupiter: The Spectacular Journey of the Galileo Spacecraft* by Daniel Fischer (Copernicus Books, New York, 2001).

WEB — Damian Peach's web site, which contains high-resolution views of Jupiter as well as images of other planets, is located at *www.theplanets.cjb.net/.*

The Association of Lunar and Planetary Observers (ALPO) maintains a web site full of observational tips and information about Jupiter at *www.lpl.arizona.edu/~rhill/alpo/jup.html.*

ASTROPHOTOGRAPHY

BOOKS — One of the best books for beginning astrophotographers is *Wide-field Astrophotography: Exposing the Universe Starting with a Common Camera* by Robert Reeves (Willmann-Bell, Richmond, Virginia, 2000). For advanced astrophotographers and imagers, be sure to read Jean Dragesco's *High Resolution Astrophotography*, translated by Richard McKim (Cambridge University Press, New York, 1995).

ARTICLES — *Astronomy* has published a large number of articles on the subject of astrophotography and CCD imaging. See, most recently, "Simple telescopic shooting" (October 2003), "A night with the Feras" (November 2003), "Imaging with webcams" (December 2003), and "CCD images at their best" (February 2004).

WEB — The large number of web sites devoted to astrophotography makes choosing just a few difficult. One of the best imagers of celestial objects is Robert Gendler. His work is displayed at *robgendlerastropics.com/.* John Chumack also produces superb astronomical images. Check out his photos at *www.galacticimages.com/galdir/homedir.html.* ■

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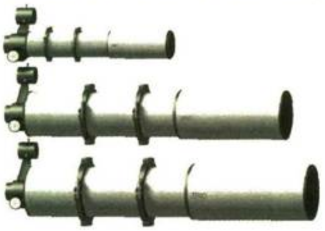

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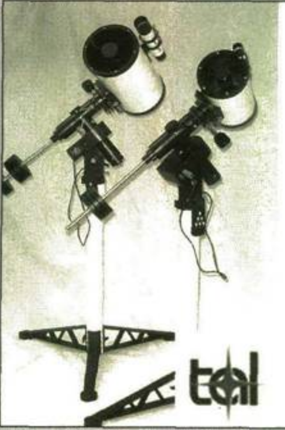

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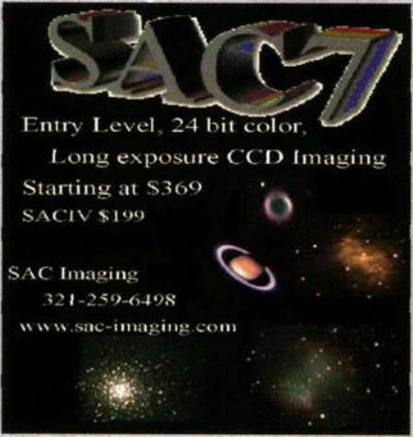

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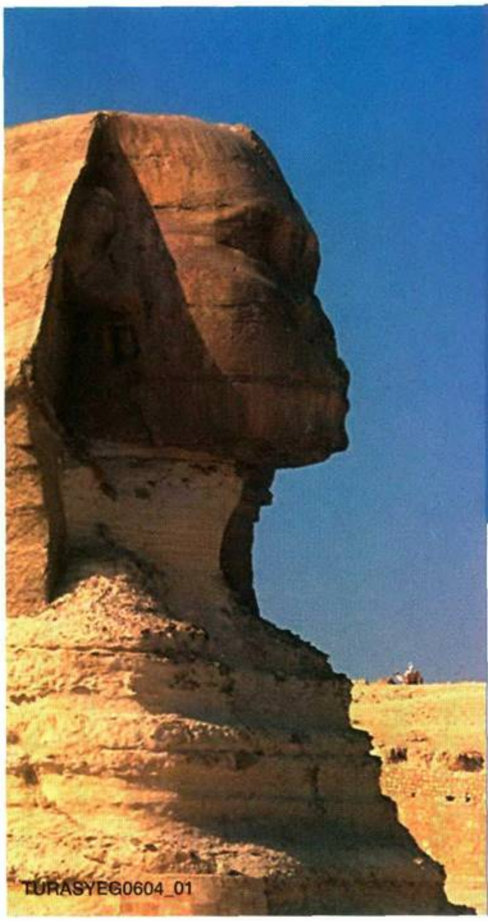

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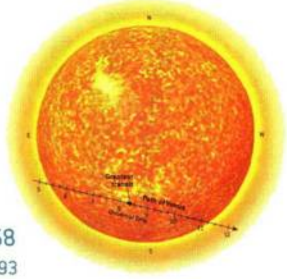

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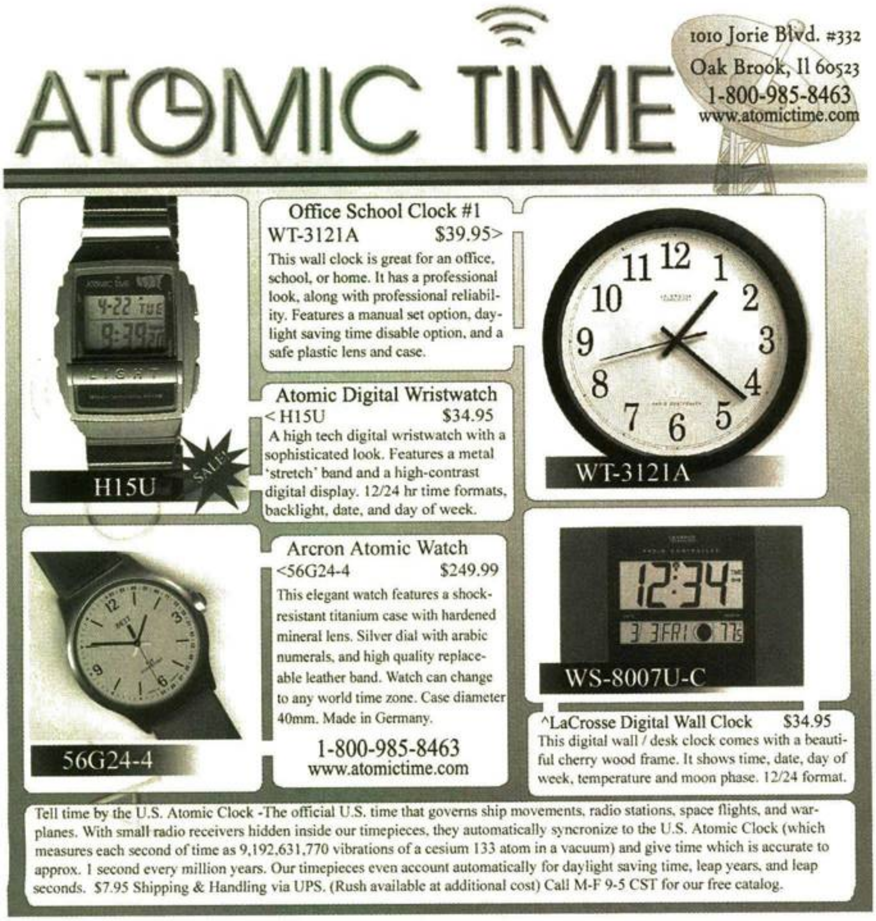
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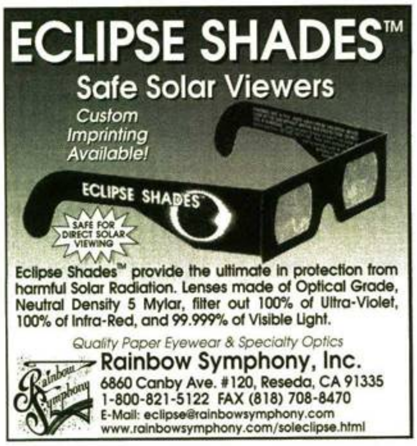
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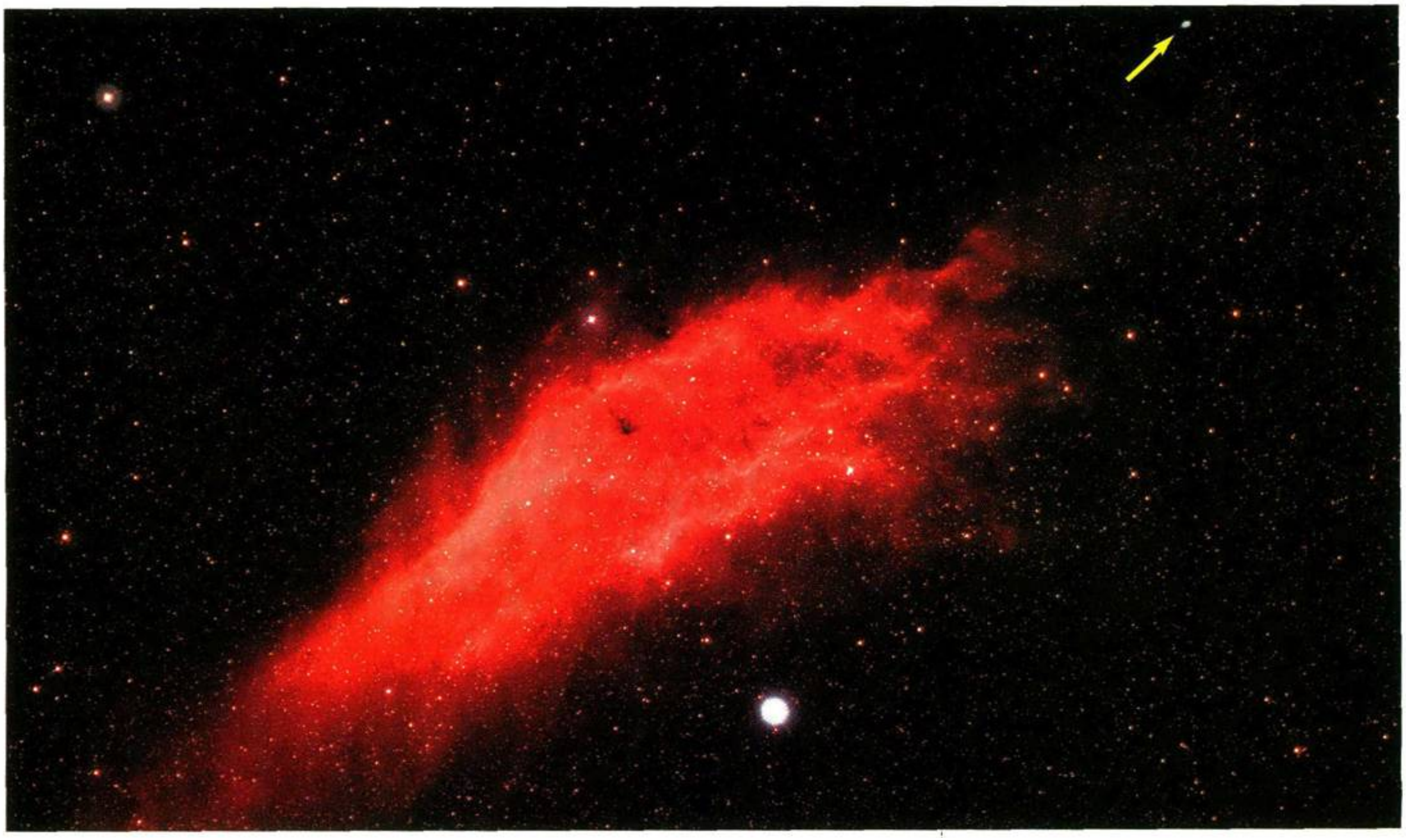

COMET 2002 T7 (LINEAR, *arrow*) AND THE CALIFORNIA NEBULA (12/16-inch Meade Schmidt camera at f/2.2, 120-format Kodak Technical Pan film, two 30-minute exposures through a #92 filter, taken at the Texas Astronomical Society site in southeastern Oklahoma) /// **JASON WARE**

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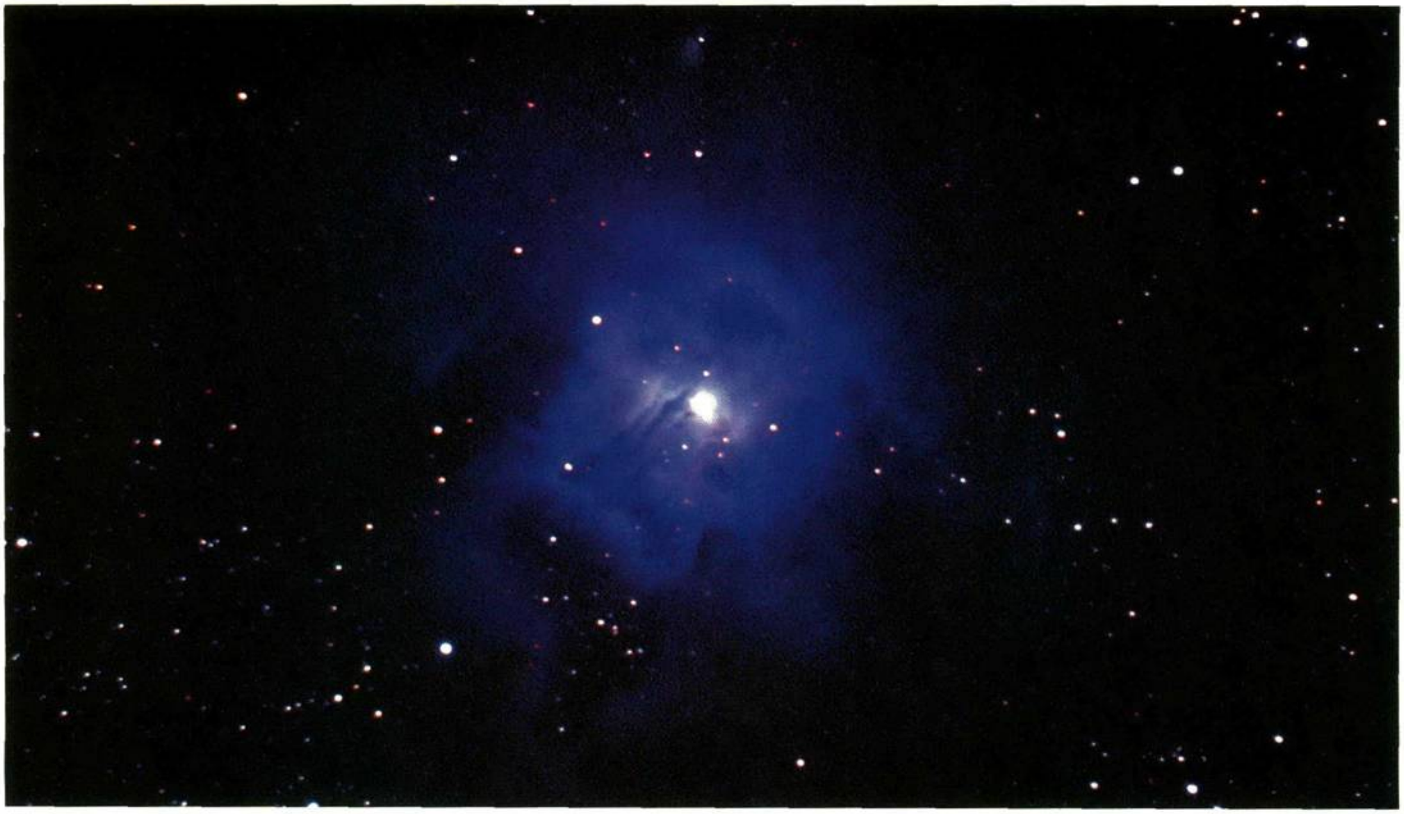
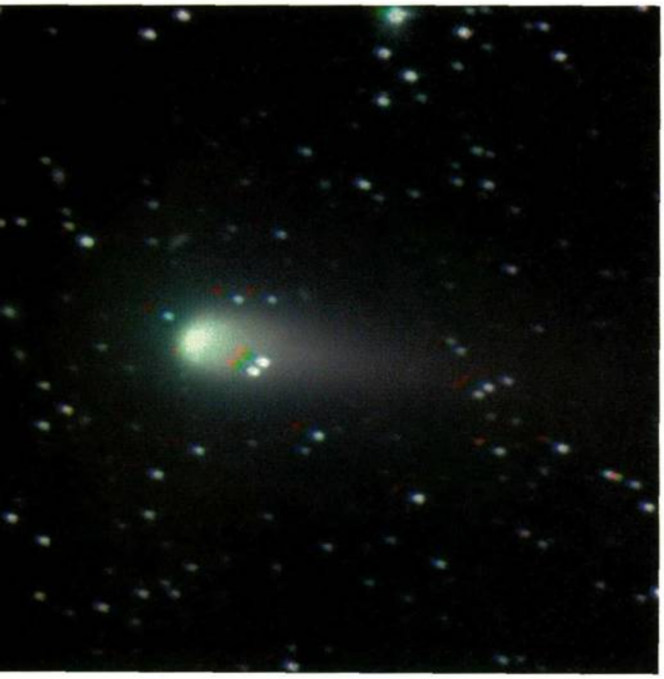
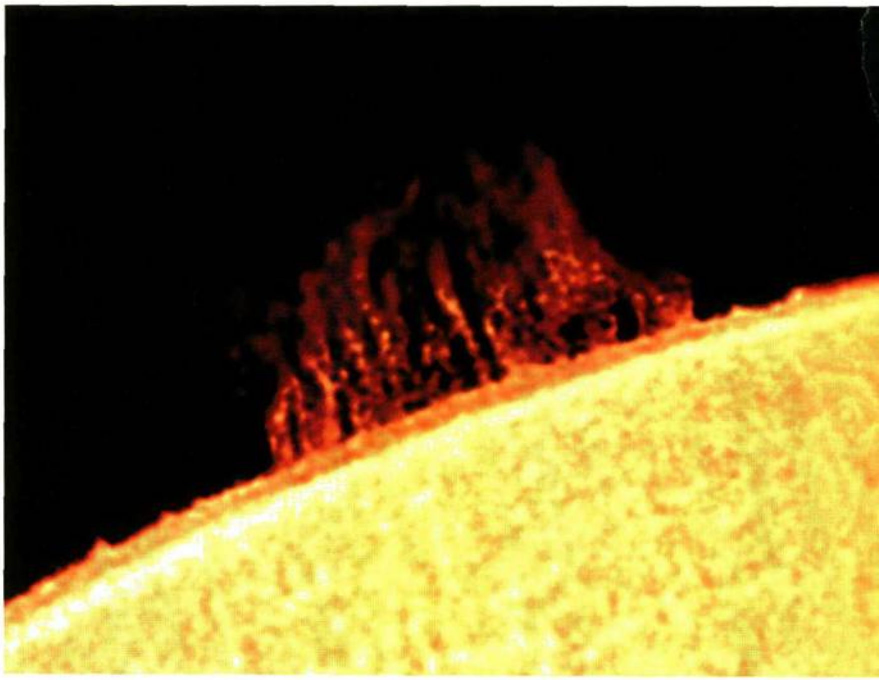




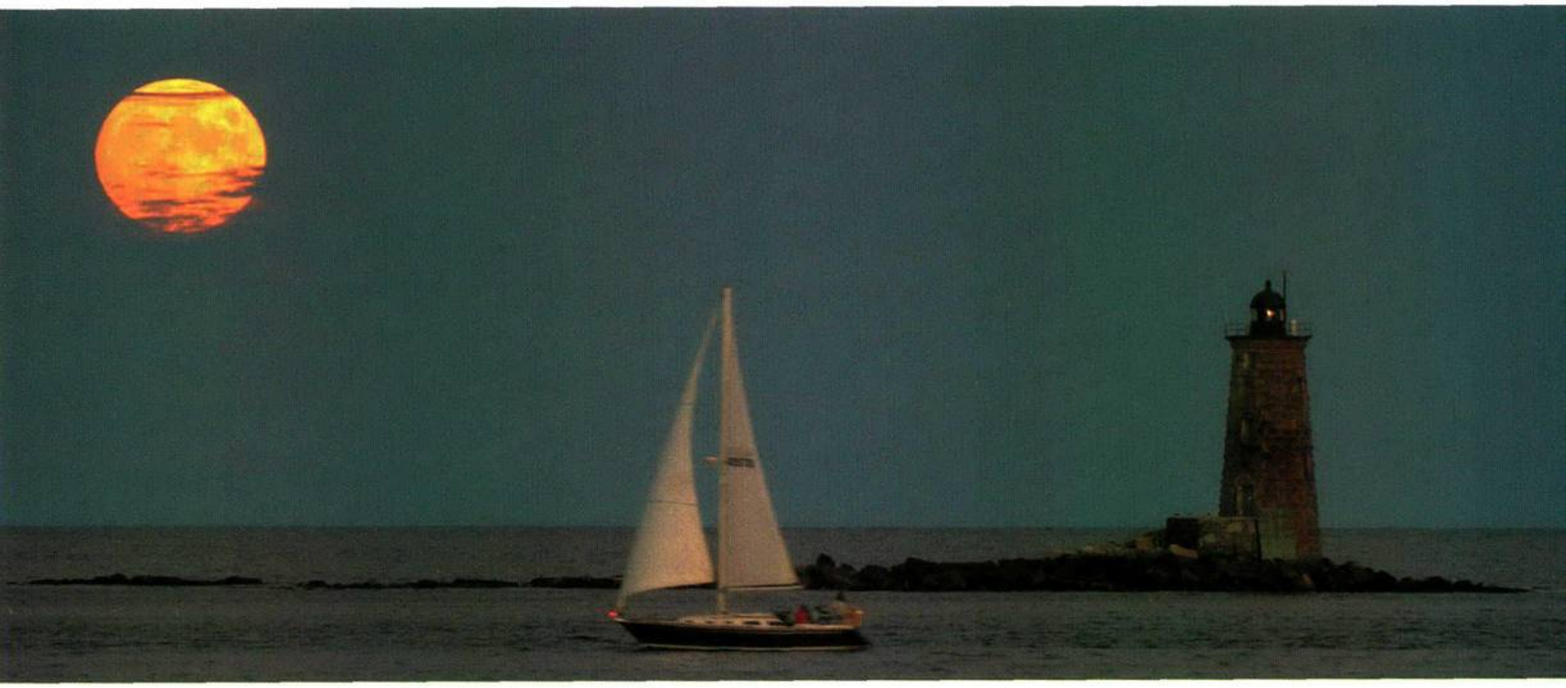


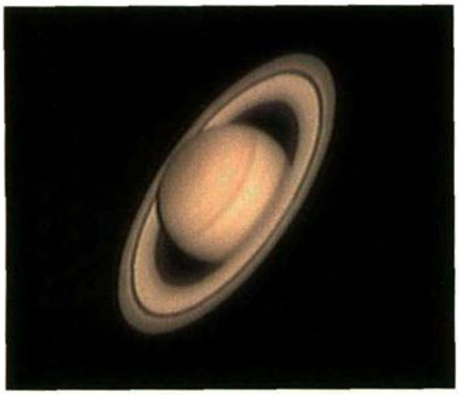
Top, **REFLECTION NEBULA NGC 7023 IN CEPHEUS** (14-inch Celestron Schmidt-Cassegrain telescope at f/7, hypersensitized 35mm Fuji Super HG 400 film, three one-hour exposures) /// **GEORGE GREANEY AND DEAN EASTON**

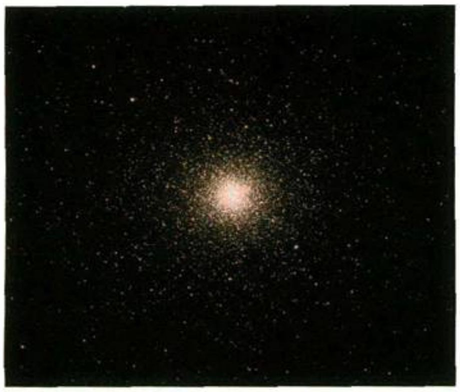
Bottom left, **COMET 2002 T7 (LINEAR)** (20-inch Ritchey-Chrétien reflector at f/8, Kodak High Resolution III film, LRGB image with exposures of 3 minutes per channel, taken December 15, 2003, at 21h02m UT) /// **PAOLO CANDY**

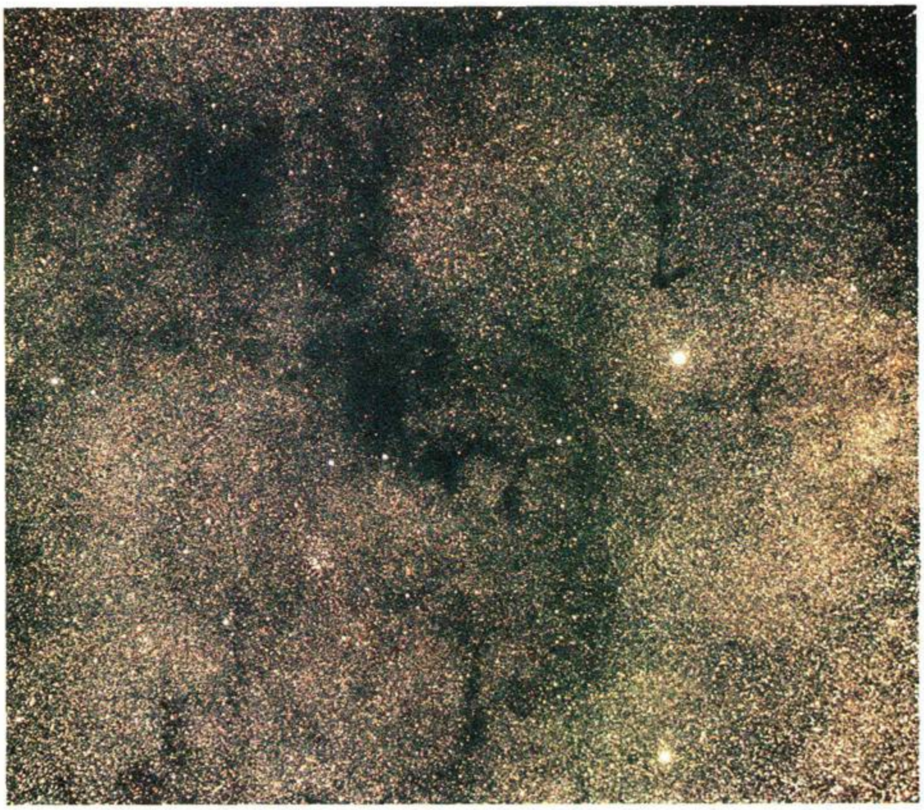
Bottom right, **HIGH-RESOLUTION SOLAR PROMINENCE** (6-inch f/8 Sky-Watcher refractor at f/30, Coronado Solarmax 40mm hydrogen-alpha filter, Sony TRV740E videocamera, taken November 5, 2003, at 13h40m UT) /// **RALF VANDEBERGH**

Below. **FULL MOON RISES BEHIND WHALEBACK LIGHTHOUSE** [Canon 10D digital camera, Sigma 170–500mm lens set to 320mm, ISO 100 equivalent, ⅙-second exposure at f/8, taken September 9, 2003, from Kittery, Maine] /// **LARRY LANDOLFI**







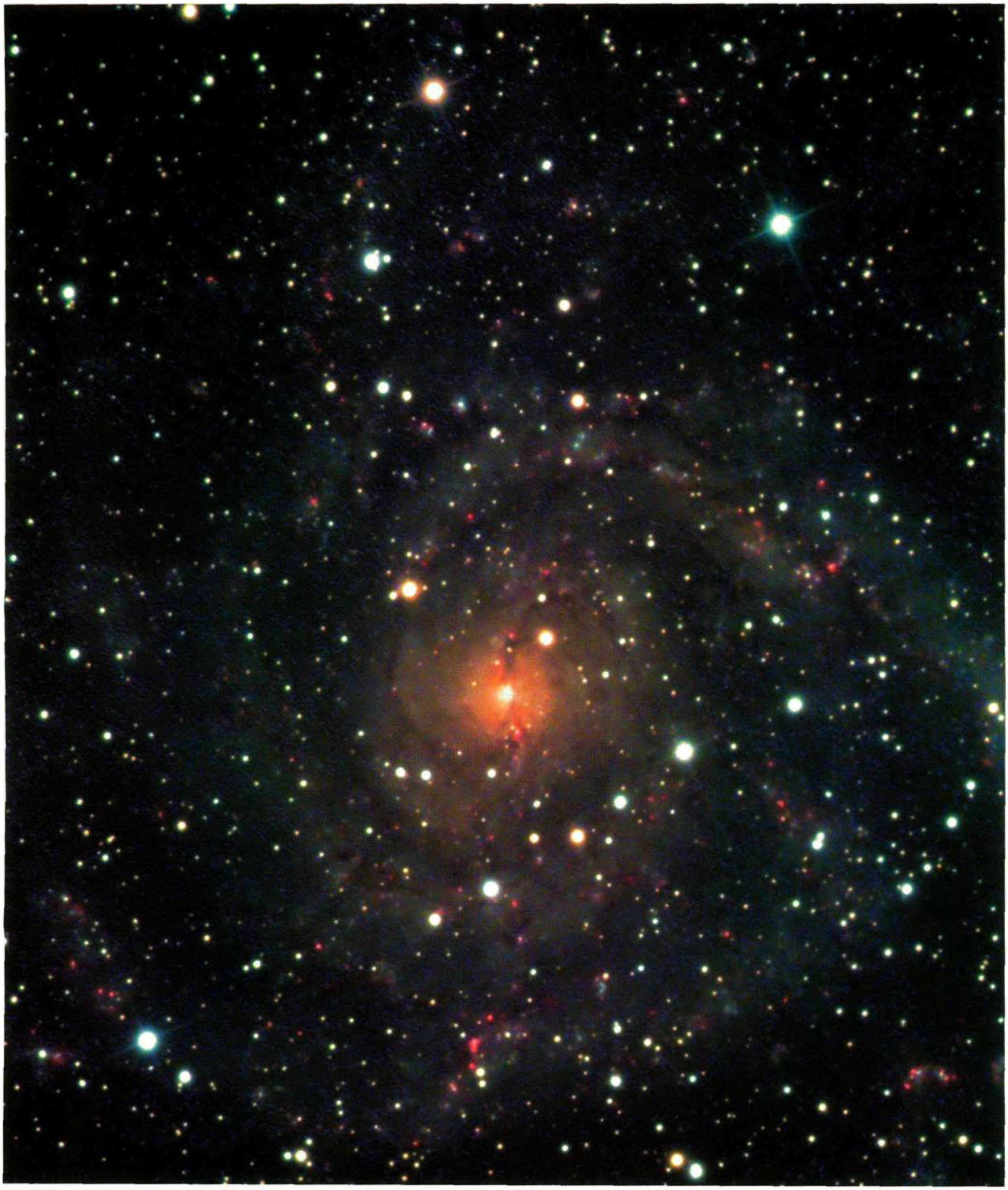


Center. **SATURN** [8-inch f/9 TMB apochromatic refractor, Philips ToUcam Pro webcam set at 2x and inserted into a 2x Barlow lens, taken November 22, 2003, at 2:00 A.M. EST from Charleston, South Carolina] /// **JIM PHILLIPS**

Bottom left. **GLOBULAR CLUSTER 47 TUCANAE** [10-inch f/6 Newtonian reflector, Kodak Gold 1000 film, push-processed to ISO 2000, 12-minute exposure taken August 28, 2000, from Namibia, Africa] /// **BRUNO MATTERN**

Bottom right. **DARK NEBULAE BARNARD 104, 110, 113, 117A, AND 119A IN SCUTUM** [6-inch Astro-Physics 155 f/7 EDF refractor, Pentax 6x7 camera, Kodak Pro 400 PPF-120 film, two 45-minute exposures stacked] /// **MICHAEL STECKER**

SPIRAL GALAXY IC 342 IN CAMELOPARDALIS (20-inch RC Optical Systems Ritchey-Chrétien telescope, IMG 6303E CCD camera, LRGB image with exposures of 60, 30, 30, and 30 minutes, respectively, taken September 21, 2003) /// **BRIAN LULA**



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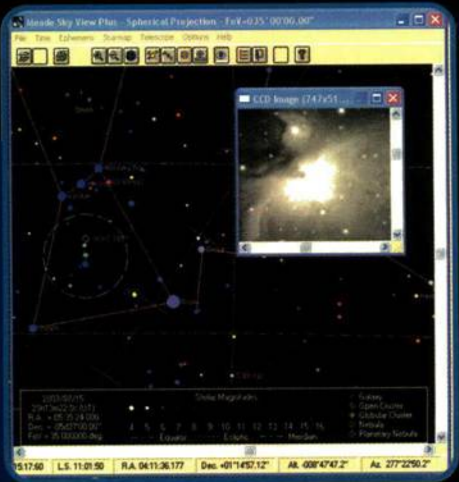
- Advanced Image Processing Software including Unsharp Masking, Convolution Filtering and many other features.
- Control all Autostar functions from a PC.
- Talking Telescope software translates Autostar text to synthesized speech through PC speaker.
- Point-and-click Autostar tour generation.
- Create observing lists and download to Autostar.
- Remote telescope control over the internet.
- Autostar Updater Tool keeps your Autostar current by downloading the latest Autostar system firmware updates; comet, asteroid and satellite data from the internet. *An exclusive Meade feature.*
- Includes cables to connect your Autostar-equipped telescope to your PC.

Meade Autostar Suite and LPI (Lunar Planetary Imager/Autoguider): For all Meade telescopes equipped with Autostar II and #497 Autostar Computer Controllers**, **complete with Autostar-PC interface cables – $149**

**For use with other Meade telescopes see the Meade web site.



Planetarium program showing Orion region.

Image of Saturn by Jeff Hobbs taken with an LPI connected to a 12" LX200GPS. The image is a composition of images automatically selected and registered by the Autostar Suite software.

Moon image taken with altazimuth mounted 8" LX90 by first-time user of the LPI imager and software.

***Visit the Meade web site at www.meade.com for complete description of features and detailed specifications.**

ADVANCED PRODUCTS DIVISION

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6001 Oak Canyon, Irvine, California 92618 ■ (949) 451-1450
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